ROBERT McKAY

TOMATO DISEASES

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Tomato diseases...

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TOMATO DISEASES

TOMATO PLANT SHOWING CHARACTERISTIC SYMPTOMS OF SPOTTED WILT,
Lycopersicum Virus 3.

TOMATO DISEASES

AN ILLUSTRATED GUIDE TO THEIR RECOGNITION AND CONTROL

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DUBLIN

AT THE SIGN OF THE THREE CANDLES

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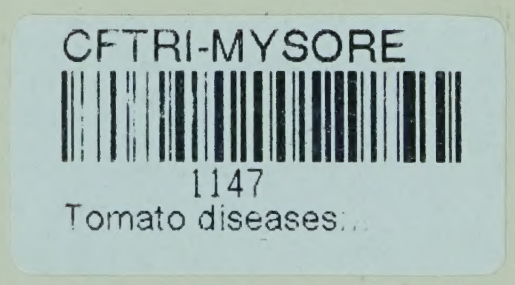

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Preface

THE object of this book is to assist growers in Ireland to identify the different maladies affecting the tomato crop, and to indicate appropriate means of control. A publication of this kind is only made possible by reference to the findings and investigations of numerous workers elsewhere. The majority of these findings, however, have been checked and tested under Irish conditions. Practically all the diseases which are described herein have passed through the writer's hands at some time or other during the past twenty years, and the troubles depicted occur in this country to a greater or less extent. Although compiled primarily for the tomato grower, it is hoped that the book may also serve as a refresher to Instructors in Horticulture, and provide a handy work of reference to nurserymen, seedsmen and others, who occasionally have to deal with queries about diseased tomatoes.

Most of the illustrations are original, but figs. 12, 13, 14, 15, 16, 17, 43, 49, 54 *and* 55 *have already appeared in the* Journal Department of Agriculture, Éire. *The article on "Root Rot of Tomatoes" has also been published in the same* Journal, *Vol. XXXIX, pp.* 272–276 ; *it is reproduced here in a slightly amended form by permission of the Department of Agriculture, Dublin, in addition to the illustrations noted.*

I should like to express my thanks particularly to the following, who one and all, freely granted permission to make use of published works :

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The authors of various articles or books and titles of papers consulted are given in the references at the end of the account of each disease.

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TOMATO DISEASES

Introduction

THE TOMATO (*Lycopersicum esculentum*) and the potato (*Solanum tuberosum*) were more or less contemporary introductions into Europe, from central and south America respectively, during the sixteenth century. In both cases their use as human food met with strong opposition in many European countries, each of them when eaten being considered detrimental to mankind. Necessity and starvation were largely responsible for overcoming this prejudice in the case of the potato, its easy cultivation and hardiness in temperate climates contributing to its acceptance eventually, but these conditions did not operate to the same extent with regard to the tomato, and the nutritional value of the latter was much slower in being realized. The Italians were apparently the first Europeans to grow tomatoes extensively for food, cultivating them as a field crop towards the end of the eighteenth century. Although well known in Great Britain during the seventeenth century the tomato was only grown as a curiosity or for ornament, and it was not until near the close of the nineteenth century that the people of these islands began to acquire a taste for the fruit and appreciate its food value. In Ireland the cultivation of tomatoes on anything like a commercial scale is an industry of recent growth, developing chiefly during the past twenty-five years. Previously the fruit was only grown to a limited extent in private gardens for home consumption, any surplus being sold locally.

The tomato is almost as easy to grow as the potato, and like it, successful crops can be raised on nearly all types of soil. Being a native of central America the tomato requires a slightly higher temperature than the potato to grow and develop properly, therefore, in this country commercial production of tomatoes is carried out under glass. With good cultivation a yield in the neighbourhood of from eight to ten pounds of fruit per plant

may be expected, but the maximum quantity possible is often curtailed by a number of agents. These are chiefly diseases caused by parasitic organisms, viruses, and unfavourable environmental conditions.

Amongst parasitic organisms fungi are the worst offenders, and from the time the seed germinates until the last fruit is picked the plants are liable to fungus attack both above and below ground. While many different species of fungi are involved, only one of them, *Cladosporium fulvum*, is specific to the tomato. All the others attack various species of plants, and though often fatal to the plant attacked, they seldom become epidemic over large areas unless conditions are particularly favourable for their development. Unfortunately such conditions are just those existing in modern glasshouses where tomatoes are grown, and they may be summarised as follows :

(*a*) The relatively large numbers of a single host species cultivated in a restricted area.

(*b*) The absence of rotation.

(*c*) Severe mutilation and wounding of plants during their growing period, due to disbudding and defoliation.

(*d*) High temperatures combined with abundant moisture.

Some of these agents also favour the spread of virus diseases, and others tend to increase the virulence of soil pests.

In addition to reduced yields caused through attacks of parasitic organisms, after a few years cropping the soil in tomato houses changes both chemically and physically. Repeated applications of organic and mineral manures frequently result in upsetting the balance of soil nutrients, and minor trace elements, which are necessary for the plant's growth, may practically disappear or be rendered unavailable. Further deterioration of the soil is brought about by heavy waterings accompanied by continual trampling, these being unavoidable in carrying out the necessary cultural operations. In stiff clay soils the two factors just mentioned conduce to waterlogging, with the inevitable reduction in the supply of oxygen ; in other types of soil they lead to the formation of a pan of hard material

at varying depths. The absence of any ameliorating climatic influence, such as frost, also plays a part, and very often the whole physical condition of the soil in a tomato house is completely changed to the detriment of the crop within a few years. This necessitates prompt remedial measures if production is to be maintained at a high level. In some instances an improvement can be got by green manuring, or by the addition of straw or similar substances to the soil which help to keep it more open. In other cases the fertility can only be restored through steam sterilization, or the worn out soil may have to be replaced with fresh loam.

For the application of intelligent control measures the first essential is the correct diagnosis of the trouble. In the following pages the grower will find a description, accompanied by illustrations, of those parasitic and non-parasitic diseases which he is likely to encounter in the course of his work, emphasis being laid on the macroscopic symptoms. Brief outlines concerning the disease producing agents as a class are given at the beginning of each section, and to these the reader is referred for an explanation of technical terms which have been used.

1. *Fungus Diseases*

FUNGI are plants, but plants devoid of CHLOROPHYLL. This is the substance which gives the green colour to grass, trees and ordinary plants, and by which they are able with the aid of sunlight to manufacture the carbon dioxide of the atmosphere into carbohydrates like starch and sugar. Lacking chlorophyll fungi are unable to perform such work and hence they must obtain some of their food ready made. For this reason, they exist either as SAPROPHYTES living on dead organic matter, or as PARASITES living on other living organisms and obtaining their food from the HOST on which they occur.

MYCELIUM is the name given to the vegetative body of a fungus, and its main function is to obtain food. A HYPHA is a single thread of the mycelium. A SCLEROTIUM is a hard compact mass of closely interwoven hyphae. It is usually a body rich in reserve food, formed to carry the fungus over a period of unfavourable conditions. When environmental factors become propitious the dormant sclerotia resume growth: in some species they simply give rise to ordinary hyphae; in others on germination they develop fructifications which serve for the rapid dissemination and multiplication of the species.

Propagation amongst fungi may be carried on by the increase and severance of separate hyphae. The more usual method of dissemination and propagation is by means of bodies called spores. A SPORE consists of one or more cells and it may be either asexual or sexual. ASEXUAL SPORES are vegetative cells abstricted from special branches. In reality they are repeating spores formed at a time when environmental conditions favour the development and spread of the fungus. In many cases after infection occurs a fresh crop of asexual spores is produced within eight or ten days. The word FRUCTIFICATION means a fruit body. Generally speaking, it is frequently used to include both the spores and the special branches on which they are borne, as well as being applied to a receptacle containing spores.

Definite names are in use for the different kinds of fructifications which occur, and also for spores possessing certain peculiarities or to indicate the manner of their formation. A ZOOSPORE is a motile spore provided with one or more FLAGELLA. The latter are whip-like appendages by means of which the zoospore is capable of independent movement in water. A ZOOSPORANGIUM is the case or receptacle in which zoospores develop. A CONIDIUM is an asexual spore borne on a special branch termed the CONIDIOPHORE. A PYCNOSPORE is an asexual spore produced inside a

flask-shaped body called the PYCNIDIUM. Very often conidia and pycnospores are simply referred to as spores.

A RESTING SPORE, or OOSPORE, is a sexually formed spore, that is, one resulting from an act of fertilization or the union of a male and female cell. Oospores correspond more or less to the seeds of higher plants. They provide for the survival of the fungus through the dormant season or through periods of unfavourable conditions for growth. ASCOSPORES are spores produced by free cell formation in large club-shaped cells termed ASCI. An APOTHECIUM is an open cup- or funnel-shaped structure bearing asci on its inner surface. A PERITHECIUM is a spherical or flask-shaped body enclosing asci. An OSTIOLE is the pore or opening in a pycnidium or perithecium through which the spores are set free. A GERM-TUBE is the tube developing from a spore on germination. SETAE are stiff hairs or bristles generally dark coloured and thick-walled.

DAMPING-OFF

DAMPING-OFF is the name given to the attack by various organisms at the base of the stems of young seedlings and herbaceous cuttings resulting in their sudden collapse and falling over, Fig. 1, Plate II. Numerous host species are liable to Damping-off, and though the disease may occur in the open the greatest damage is done to plants raised under glass, tomato seedlings frequently suffering severely. Several species of fungi are associated with this trouble and most of them are common soil inhabitants, living on decaying plant material, but capable of becoming parasitic when opportunity occurs. The usual organisms causing Damping-off in tomato seedlings are, *Phtophthora cryptogea* Pethybr. & Laff., *Phytophthora parasitica* Dast., and to a lesser extent *Corticium Solani* Bourd. & Galz., but others may occasionally be responsible.

SYMPTOMS. Typically the attack in all cases is the same. Hyphae of the causal fungus spread mainly through the surface layers of the soil and infection occurs by direct penetration of the tender host tissues just at soil level. Under moist conditions existing amongst thickly crowded seedlings the *Phytophthora* species fructify on diseased stems, producing zoosporangia which

when mature liberate zoospores. The zoospores swim away in the film of water present on the soil surface and infect neighbouring healthy plants. Damping-off may appear on seedlings within a few days after their emergence from the soil and collapse of plants may occur even before wilting of the tops is noticeable. Under conditions favourable for the development of the disease many seedlings may be destroyed within a few days. When slightly older plants are attacked the infected areas display a brownish water-soaked appearance, accompanied by more or less constriction of the stem due to the destruction of the cortical tissues, Fig. 2, Plate II. The consequent interruption to the flow of water and food materials from the root to the top of the plant results in wilting and collapse, and as the tissues in the infected areas have been killed recovery is impossible. The progress of the rot is often restricted to a limited region of the stem but this is only because the atmosphere in its vicinity is saturated with moisture. After the plants have fallen over they may continue to decay until completely rotted, or under dry conditions shrivel up. In addition to appearing in seed-boxes, Damping-off not infrequently develops within a few days after the plants are set out in their permanent quarters. This can nearly always be traced to the check given to growth subsequent to transplanting, which predisposes the plants to invasion by soil fungi.

FOOT ROT AND COLLAR ROT. These are names given to late attacks of Damping-off organisms on the plant, and where, owing to the development of woody tissue before the attack occurred, the plants remain erect after the cortex has been destroyed, Fig. 7, Plate IV. This phase of the disease is more common after the final transplanting than during the earlier stages of growth.

Conditions favouring the development of Damping-off may be summarised as follows :

(*a*) The use of composts rich in humus or organic matter for raising the seedlings. It is on such material that most of the fungi responsible for the disease live and by it are introduced into the propagating beds.

(*b*) Thick sowing which gives rise to thin "drawn-up" plants with immature tissues, and to the formation of a continuous water film at the base of the plants, thus facilitating the spread of the disease through the seed-boxes.

(*c*) High temperatures in propagating houses resulting in the production of soft succulent growth liable to invasion. Temperatures between 20 and 30°C. (68–86°F.) favour the growth of the parasitic organisms concerned but their growth almost ceases in the neighbourhood of 12°C. (53°F.).

(*d*) Excess moisture due to waterlogging of the seed-boxes, and caused either by bad drainage or over-watering.

(*e*) Environmental conditions in the house at the time of transplanting which do not favour the immediate renewal of growth ; that is, those which induce high transpiration or a wet cold soil.

CONTROL MEASURES. These revolve about the fore-going points. A rich soil is not necessary for raising seedlings, and thin sowing results in sturdy well developed plants capable of resisting attack. The watering and ventilation can be so manipulated that the soil will remain uniformly moist to support growth but will at the same time dry out at its surface, and on the appearance of the disease the temperature should be kept as low as possible compatible with maintaining growth of the plants. The virulence of Damping-off depends mainly upon the conditions of temperature and moisture, but in severe attacks only limited control is possible by attention to these factors. Other methods, available for checking the disease or entirely preventing it, are treatment with chemicals and sterilization of the soil.

(*i*) CHESHUNT COMPOUND. The spread of the disease in seed-boxes can be checked by watering with a solution known as the "Cheshunt Compound," which was first used and recommended by Bewley (1) in England. The compound is prepared by mixing two parts by weight of powdered copper

sulphate with eleven parts of freshly ground ammonium carbonate. The dry mixture is placed in a glass or earthenware jar which is then tightly stoppered and allowed to stand twenty-four hours before using. Provided the container is airtight, the dry preparation will keep perfectly for a long time. When required for use, one ounce of the dry mixture is dissolved in a little hot water and then made up to two gallons with cold water. The solution is applied with a watering can to the soil at the rate of one quart per square foot. The disease organisms in the soil are destroyed by this solution which at the same time is harmless to the plants. The solution corrodes vessels of iron, tin or zinc, and only just as much as is required for immediate use should be prepared. As a preventative of Damping-off, it is recommended that the soil in the seed-boxes should be thoroughly watered with the solution after sowing and covering the seeds, and the young plants should also be watered with it before and after transplanting into pots. When plants are attacked subsequent to planting out in the houses, they should be removed and the site watered with one pint of the solution, after which a healthy plant may be inserted and watering with the solution again carried out.

(*ii*) POTASSIUM PERMANGANATE. Because of the cost and troublesome method of preparing "Cheshunt Compound" a cheap and effective substitute is available in potassium permanganate. Cunningham (2) recommends a strength of one ounce of this chemical dissolved in one gallon of water, and applied at the rate of one quart per square foot of soil at ten day intervals.

(*iii*) STERILIZATION OF SOIL BY FORMALDEHYDE. Owing to the general prevalence of Damping-off organisms in the soil, all soil used for seed-boxes and for raising the young plants should be sterilized. Where steam or heat is not obtainable, sterilization is most readily effected by treating the soil with formaldehyde. One gallon of the forty per cent. formaldehyde is mixed with forty-nine gallons of water. A layer of soil five to six inches deep is spread out on a clean floor, or on ground which has been tramped firm, and saturated with

the above solution. Other layers are added and saturated in turn until all the soil necessary has been treated. All seed-boxes and pans should be sterilized at the same time by dipping them in the formaldehyde solution. Tarpaulins or sacks wetted with the solution are then used for covering the heap of soil and seed-boxes, in order to confine the fumes. At the end of forty-eight hours the covering may be removed and the soil spread out to dry. Formaldehyde treatment is generally carried out about a fortnight before the soil is required, and no sowing should be done until all smell of the chemical has disappeared from the soil. Care should be taken after treatment to ensure that the soil does not become contaminated again.

(*iv*) STERILIZATION OF SOIL BY HEAT. Small quantities of soil for propagation purposes may be sterilized by baking or steaming. Both methods have their advocates. A suitable apparatus for treatment may be improvised at home or one of the various manufactured sterilizers purchased.* Soil for baking should be reasonably dry, and the bulk uniformly heated to 205-210°F., this range of temperature being maintained for one to two hours. As baking changes the physical condition of the soil, treatment should be carried out six weeks before it is required, the soil being stored in the interval in a clean shed. Failing the lapse of this period between treatment and use, baked soil should be soaked with water several times, as this helps to restore the original physical condition to some extent. Both baking and steaming destroy disease organisms and when properly carried out increase the fertility of the soil, but in hands of the inexperienced baking is liable to be overdone. When soil is overheated it is rendered completely sterile and seedlings make no growth in it.

During steaming it is almost impossible to overheat the soil and many devices have been invented for treating soil by this means. Steam is introduced into the soil and the treatment

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* Different forms of steaming and baking sterilizers are described in *Practical Soil Sterilization*, Bulletin 22 of the Ministry of Agriculture and Fisheries, London. Price 1*s.* 3*d.* net.

continued for another thirty to forty minutes after the soil temperature has reached 210–212°F. Steam sterilized soil should not be used for at least three weeks after treatment.

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1. Bewley, W. F.—Control of "Damping-off" and "Foot Rot" of Tomatoes. *Journal of the Ministry of Agriculture, London*, Vol. xxviii, pp. 653-4, 1921.
2. Cunningham, C. H.—*Plant Protection by the Aid of Therapeutants.* 1935.

TOMATO LEAF MOULD

Cladosporium fulvum Cooke

This fungus, *Cladosporium fulvum*, was first described by Cooke in 1883 from material received from Carolina, North America, and the earliest account of its occurrence in Europe is that by Plowright in the *Gardener's Chronicle* in 1887. (2). It is obvious from the latter's article that the disease had been present in England to some extent in 1886 and that the serious nature of it was realized from the time of its first appearance in the Old World. Since then, *Cladosporium fulvum* has been recorded from practically all countries where tomatoes are grown. The fungus is considered to be specific to the tomato plant, but it has also been listed as occurring on the egg plant (*Solanum melongena*) in the Dominican Republic, Ciferri (1).

Tomato Leaf Mould attacks outdoor tomato plants and occasionally may be severe on such plants in a shaded, humid position, but the disease is essentially one of glasshouse crops. The greenhouse conditions provide the factors of high temperature and humidity necessary for the maximum development of the fungus. The disease may occur in newly erected glasshouses and it can appear at any time during the growing season. It is usually first noticed about the end of May or beginning of June, and unless checked, its ravages become severe during July and August.

SYMPTOMS. Leaflets of all ages are susceptible to attack, the disease being generally first seen by the grower on the older terminal leaflets. Pallid spots or blotches, which afterwards turn yellow, appear on the upper surface of the foliage, Fig. 3, Plate III, and an examination of the under side of these pale areas reveals a dense furry growth present, Figs. 4 and 5, Plate III, which is greyish at first but later turns cinnamon brown. This growth consists of the fructifications of the fungus and at the beginning of an attack it is confined to the lower surface of the leaf. Under favourable environmental conditions the infected areas rapidly increase in size and number, the diseased leaf curls up and the fungus also appears on its upper surface, until eventually the whole leaf becomes covered with fructifications of the parasite and it then presents a dirty brown woolly appearance. The injury to the foliage retards and checks the development of the fruit, and though badly diseased leaves are killed they do not necessarily fall from the plant. The development of the disease is worst on the lower denser parts of the foliage ; in bad attacks it may also cover the entire top of the plants. The spores of the fungus are easily detached from the branches which bear them, and are disseminated by air currents, clothes of the workers, or other agencies throughout the house. Where the attack is severe any movement of the plant sets whole clouds of spores in motion. Under the humid conditions existing in the greenhouse the spores germinate readily and infection of the leaves follows, infection in each instance resulting in the production of more spores.

Although Tomato Leaf Mould is generally only observed by the grower on the leaves, the fungus also attacks the flowers and fruit direct, gaining entrance mainly from the sepals. The attack on flower trusses may be so severe that serious reduction in yield sometimes occurs from this phase of the disease alone. Infection of the ovaries in young fruit results in their arrested development and premature fall, and invasion of more mature fruit may be followed by darkening and more or less rot of the stem-end, although the fungus does not apparently fructify on the fruit itself.

PLATE II

FIG. 1

FIG. 2

FIG. 1. DAMPING-OFF IN TOMATO SEEDLINGS DUE TO *Phytophthora cryptogea*.

FIG. 2. SLIGHTLY OLDER PLANT SHOWING CONSTRICTION AND COLLAPSE OF STEM AT SOIL LEVEL DUE TO DAMPING-OFF.

PLATE III

FIG. 3

FIG. 5

FIG 4

FIG. 3. PALLID SPOTS ON UPPER SURFACE OF TOMATO LEAFLET CAUSED BY ATTACKS OF TOMATO LEAF MOULD, *Cladosporium fulvum.*

FIG. 4. UNDER SURFACE OF LEAFLET ATTACKED BY TOMATO LEAF MOULD.

FIG. 5. ENLARGED VIEW OF DISEASED SPOT ON LOWER LEAF SURFACE SHOWING DENSE WEFT OF THE FUNGUS *Cladosporium fulvum.* X3.

Infected seed and seed contaminated with fragments of diseased fruit have been shown to propagate the disease when sown, and it is probably by such means that the parasite has become so widely distributed. Nevertheless, the survival of the disease from one season to another is believed to be due mainly to its spores. Though the latter germinate readily under favourable conditions of temperature and humidity, they are very resistant to dryness and low temperature and they can remain viable for eight or nine months.

As already mentioned, the attack at first is confined to the lower surface of the leaves, conditions favouring its development here being :

(*a*) The checking effect which bright sunlight has on the fungus.

(*b*) The greater humidity of the under surface of the leaves which favours spore germination.

(*c*) Stomata are more numerous on the under sides of the leaves than on the upper surface, thereby facilitating infection.

The development of the fungus is favoured by a temperature of about 72°F. accompanied by an atmospheric humidity of over ninety per cent. The latter, however, is much the more important factor of the two for the growth of the fungus.

CONTROL. (*i*) CULTURAL OPERATIONS. When the disease first appears good cultural operations help in checking its spread. As the development and spread of the disease are closely related to the temperature and humidity, thorough ventilation of the house is essential, and the atmosphere should be kept as dry as possible. At a temperature of about 55°F. and a relative humidity of fifty-eight per cent. the fungus makes practically no growth, but any increase in temperature up to 72°F. accompanied by a higher atmospheric humidity favours the fungus. As the disease is worst on the lower leaves, and in any case these eventually turn yellow, all those below the ripening truss should be removed. This, together with judicious thinning of any dense upper foliage allows circulation of air and penetration

of sunlight amongst the plants. Both these factors aid in keeping the disease in check. Watering of the houses should be carried out in the morning in order that the air and soil surface will dry out as much as possible during the daytime : and it should be remembered that dry conditions during the day do not counteract excessive humidity at night. Ventilation, therefore, must be adequate throughout the twenty-four hours. Frequently during the months of July and August, when conditions are particularly favourable for the fungus, its development may be retarded by leaving the ventilators and doors open all night.

(*ii*) FUNGICIDAL TREATMENT. Vaporization with sulphur and spraying with sulphur compounds may occasionally prevent the disease becoming severe, but such treatments tend to form a deposit on the fruit which is difficult to remove and scorching is liable to occur. For these reasons, when it is desired to try control by fungicides, recourse is now had either to a spray made from a paste of Salicylanilide containing a wetting agent, or to one of the colloidal copper sprays. Preparations of these new spray materials are readily available from most seedsmen and manufacturer's agents throughout the country. The directions accompanying these proprietary sprays should be strictly adhered to, if not, injury to the plants may follow.

For any fungicidal treatment to be effective it requires to be carried out in conjunction with proper ventilation and in the early stages of disease development, and frequent treatment throughout the growing period is required. It is also important to use machines capable of high pressure for spraying, as all foliage should be thoroughly covered and the fungus growth on the leaves is difficult to wet.

Spraying for the control of Tomato Leaf Mould has never become a common practice, and the vast majority of commercial growers rely on good cultural methods for keeping the disease in check, supplementing them if necessary by a little artificial heat throughout the season in order to maintain a dry atmosphere.

(*iii*) GENERAL HYGIENE. At the end of the season the house should be disinfected in some manner and all plant remains burnt. For disinfection of greenhouses sulphur fumiga-

tion is the most economical and practical, as the fumes are lethal to both insects and fungi. The burning of sulphur should be done just before the old plants are removed, and during the operation it is desirable that dry conditions exist. The usual rate of application recommended is one lb. flowers of sulphur to each 1,000 cubic feet, but even at half this rate the fumes have been shown to be fatal to the spores of *Cladosporium fulvum*. Wood wool or similar material is distributed in little heaps throughout the house and the requisite quantity of sulphur placed on them, the heaps being then ignited. All ventilators and doors are kept tightly closed for 48-72 hours afterwards. In houses with zinc trellis or wires, or where paint containing this metal has been used for interior painting, chemical reactions with sulphur occur, and the resulting residues in drip water cause severe injury to young plants. Therefore, sulphur should not be burned except where the interior is free from zinc.

As an alternative, where corrosive action is liable to occur, the house may be washed down with formaldehyde, one gallon of the forty per cent. liquid to forty-nine gallons of water. The spray should be forcibly applied and the nozzle held close to the roof and walls so that all crevices are penetrated, and the glasshouse kept closed for four days following treatment. Formaldehyde vapour has a lethal effect on fungi but it possesses little insecticidal value. Goggles should be worn to protect the eyes during spraying, and reasonable care should be exercised, as formaldehyde vapours have an irritating effect on the mucous membranes of the nose and throat.

(*iv*) RESISTANT VARIETIES. A number of varieties have been reported as resistant to Tomato Leaf Mould, but none is immune to the disease, as strains of the fungus occur which are capable of attacking the most resistant kinds. A greater drawback to these resistant varieties has been the poor quality of their fruit and low yields. Hence, none of them has found favour with commercial growers. Breeding for resistant or immune varieties possessing good quality combined with heavy cropping characters is still in progress at various research institutions.

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GREY MOULD

Botrytis cinerea FR.

Botrytis cinerea Pers. is an old specific name applied to a group of loosely defined fungi which develop the well known greyish-brown fructifications, and large, black, flattened sclerotia adhering closely to the substratum. Such forms occur on a large number of host species, they may exist as saprophytes, but under favourable environmental conditions they often become parasitic and can be very destructive.

The common name Grey Mould is that given to the characteristic fructifications. These consist of conidiophores, each of a single stalk, or with a few branches, terminating in a head of spores, rather like a minute bunch of grapes. The sclerotia are black on the outside and white within, and consist of masses of interwoven fungal threads. Usually they include within their tissues some of the fibres of the host plant on which they were formed, and hence, they do not fall away readily from their host even after its death. The sclerotia are resistant to drought and frost and enable the fungus to survive unfavourable conditions. In warm moist air they produce fructifications quickly, the spores being practically always of the conidial type. The conditions under which sclerotia give rise to conidia are just those favourable for infection by the numerous powdery spores dispersed into the atmosphere.

Grey Mould is common on many plants grown under glass, but on none are its ravages so severe as on the tomato.

SYMPTOMS ON TOMATO PLANTS. These are somewhat variable depending on the part of the plant attacked.

FIG. 6

FIG. 7

FIG. 8

FIG. 6. THE GREY MOULD, *Botrytis cinerea*, ATTACKING TOMATO STEM THROUGH BADLY PRUNED LEAF BASE.

FIG. 7. FOOT ROT OF TOMATO STEM CAUSED BY *Botrytis cinerea*.

FIG. 8. TOMATO STEM ROT CAUSED BY THE GREY MOULD FUNGUS.

PLATE V

FIG. 9

FIG. 10

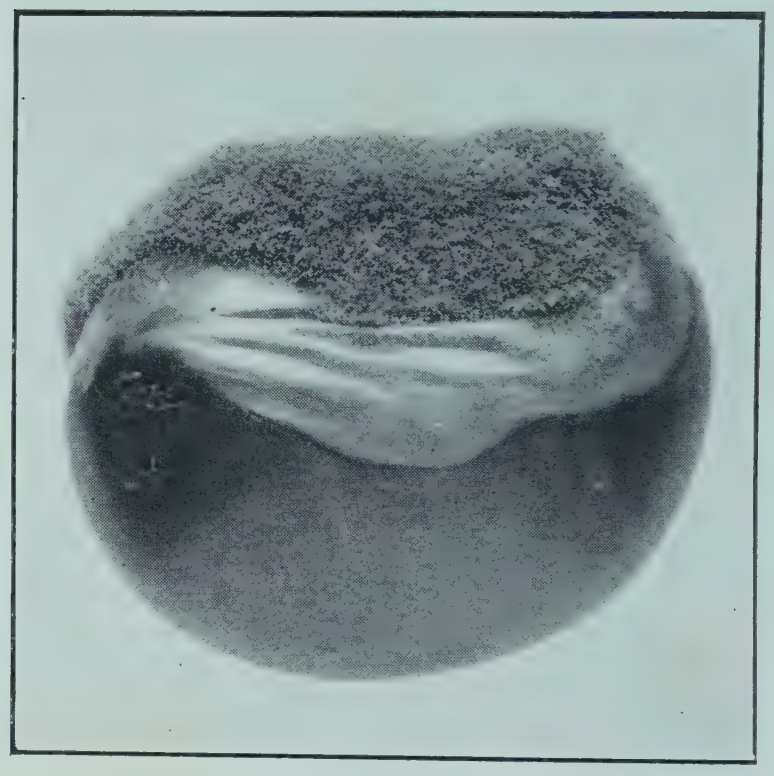

FIG. 11

FIG. 9. WATER SPOT (' GHOST SPOT ') ON TOMATO DUE TO *Botrytis cinerea*.

FIG. 10. THE GREY MOULD FUNGUS ATTACKING AND KILLING TOMATO FOLIAGE AND CAUSING WATER SPOT ON TRUSS BELOW DEAD LEAVES.

FIG. 11. *Botrytis cinerea* FRUCTIFYING ON TOMATO.

The fungus may sometimes be responsible for Damping-off, but attacks at soil level generally take place after the plants have been set out in their permanent quarters so that Foot Rot is the result, Fig. 7, Plate IV. Grey Mould may occur on any part of the plant above ground, but the most serious phase of the disease is the attack on the main stems, producing a typical Stem Rot. The fungus is nearly always present on any dead or dying foliage, and it gains entrance into the stem through leaf stalks, wounds and badly pruned leaf-bases, Fig. 6, Plate IV. Having entered, it spreads up and down the stem killing the cells ; the affected tissues shrink somewhat and their surface turns ashy-grey to brown. The sunken diseased area may extend along one side of the stem for several inches, and one or several such areas may be present on a single plant. The depth of fungus penetration into the stalk varies considerably, and in the larger lesions it generally reaches the pith cavity at some point. Occasionally the stem may be completely girdled by the fungus in which case it collapses. Fructifications of the fungus develop on the dead portions, and under the moist conditions usually existing in the glasshouse the whole of the diseased area becomes covered with the well known dirty Grey Mould, Fig. 8, Plate IV. The spores are freely disseminated by air currents, watering and other cultural operations. They germinate readily under moist conditions and infect fruit, pedicels, petioles and leaf scars. After becoming established in such places the fungus gains vigour and invades the healthy stem tissues.

Attacks on the fruit may either develop into a soft rot or remain as blemishes. The former is the more common, the symptoms first appearing as pale water-soaked spots which rapidly increase in size, their development being accompanied by general collapse of the infected parts. Invasion of the fruit in many cases takes place mainly from the calyces, although other points beside the stem-end may sometimes be attacked. As the rot spreads, the skin over the diseased portion frequently forms into slight ridges or folds, and under suitable environmental conditions it soon becomes covered with a copious growth

of fructifications, Fig. 11, Plate V. Infection of this type very often arises from *Botrytis* growing on dead flowers which drop and get caught in the branches of a developing truss.

Blemishes and spotting of the fruit occur as the result of *Botrytis* spores germinating on the fruit surface when it is covered with a film of moisture, but though penetration of the epidermis follows infection is not completed, because, owing to a return to drier conditions the germ-tube dies. Such blemishes vary in size from 0.5 mm. to almost 1 cm. in diameter and consist of a brownish puncture surrounded by a pale yellow or clear ring, Fig. 9, Plate V. Water Spot is the name usually applied to such blemishes. Ainsworth and Oyler (1) have shown that the ring development is due to the pectinase enzyme secreted by the germ-tube diffusing outwards from the puncture and dissolving the middle lamella of the cell walls. This spotting of tomato fruit develops worst on the basal part of fruit in trusses below leaves which are being killed by *Botrytis*, Fig. 10, Plate V. The injury, although often well marked on green fruit as pale green or silvery rings, disappears more or less as the fruit ripens or develops colour. A somewhat similar marking of tomato fruits in America is known by the name of "Ghost Spot," Doolittle (2).

CONTROL. Grey Mould is never serious where environmental conditions favour the production of good healthy foliage. Spore germination and infection do not take place when the air is moderately dry, accordingly, sanitation and a relatively dry atmosphere with efficient ventilation are the chief factors necessary for control. When Foot Rot due to *Botrytis* occurs, nothing can be done to save the plants and they should be pulled up at once and destroyed. All damaged or infected foliage should also be removed and no dead leaves left lying about. Unwanted foliage should be cut clean away close to the stem, and leaves should not be torn off, as all jagged wounds and stubs of leaf bases are slow to heal and subject to infection. Where Stem Rot is noticed at leaf scars or similar places, the progress of decay may be stopped by cutting out all diseased tissue and then painting the cut surface with a strong solution of copper

sulphate or of sulphide of potassium (liver of sulphur). Alternatively, the clean cut surface may be rubbed with a moistened lump of either chemical. Any fruit showing soft rot should be removed immediately.

Cleansing of the house, as recommended for control of Tomato Leaf Mould, should be a regular procedure at the end of the growing season.

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TOMATO ROOT ROT

Colletotrichum atramentarium (Berk. & Br.) Taubenh.

Several plants from widely separated families are liable to be attacked by this fungus, but in the past, it has apparently been recorded more frequently from the potato than from any other host. Notwithstanding this fact, many investigators believe that *Colletotrichum atramentarium* is merely a weak parasite on the potato, acting more in the role of a " camp follower " than anything else, and only capable of establishing itself on plants which have been injured or weakened by other enemies or unfavourable environment. Its frequent association with such virulent potato parasites as the potato eelworm *Heterodera rostochiensis*, *Verticillium albo-atrum* and *Fusarium* species supports this opinion.

While some doubt exists as to the amount of damage solely done by *Colletotrichum atramentarium* to potato plants, there is none whatever with regard to its destructiveness on tomato roots. The first record of Root Rot of Tomato in Great Britain or Ireland is that by Bewley in England in 1921 (1) and since then the disease has been reported many times. This Root Rot is one of the commonest and most ruinous maladies attacking

tomato plants in Ireland. Records kept during the period 1940–'48 inclusive, show that *Colletotrichum atramentarium* was the only parasitic organism present on twenty per cent. of all diseased tomato plants submitted for examination to the Department of Plant Pathology.

SYMPTOMS ON TOMATO PLANTS. The disease is generally noticed by the grower about the third or fourth year in which tomatoes have been grown in the same soil. Plants of the same variety become irregular in height, their tops thin and spindly, and trusses above the third often fail to set fruit, most of the blossoms falling. The latter feature is, of course, a common one following any interruption to the water requirements of the plant. During bright warm weather the tops and upper foliage of infected plants wilt in the daytime, but recover more or less at night. The extent to which each of these features develops is dependent on the quantity of feeding roots still functioning, and also on the existing climatic conditions. It is not unusual to find plants wilting badly during the day and appearing almost normal the following morning. When wilted plants are pulled up, they part readily from the soil owing to their poor root system. When the latter is washed under a water tap, an examination reveals that almost all the finer feeding roots have been destroyed, and the cortex of many of the older roots is broken up and decayed. The injury to the cortex is very characteristic; portions of it may have completely disappeared leaving the white central core of the root exposed, and that still remaining is cracked across at irregular intervals and loosely attached, so that it moves easily on the woody core. In some cases the cortex of the roots may be so completely destroyed that the roots, when washed, seem at a glance to be white and healthy looking, this appearance being caused by the stripped, white woody cylinder. Occasionally the fungus may also destroy the cortex of the stem at soil level, simulating Foot Rot. This phase of the disease is not a common symptom on mature plants, but it may be common on young plants which are raised in infected soil. Typical symptoms of Foot Rot are shown in Fig. 15, Plate VIII.

Diagnosis of the disease is finally concluded by finding small black sclerotia of the fungus *Colletotrichum atramentarium* present on the damaged roots after washing. The sclerotia appear as small black specks, just visible to the naked eye, or with the aid of a pocket lens. They may be found either on the white woody core of the root, which has been stripped by the fungus and where they show up plainly, or on portions of injured cortex where they may occur in large numbers, Fig. 16, Plate VIII. Generally speaking, sclerotia are most abundant on the cortex of diseased roots, though sometimes their development appears to be restricted to parts adjacent to the main stem of the plant. They are somewhat variable in size but seldom exceed $\frac{1}{2}$ mm. in diameter, and setae may be absent or well developed as in Fig. 17, Plate VIII. The setae only become visible when sclerotia are examined with a microscope.

Unless some treatment of the soil is carried out, the disease becomes progressively worse the following year. As soon as ever the young plants are set out in the house their roots are attacked. This soon becomes apparent from the unevenness of the plants, some make little growth from the start and remain more or less at a standstill ; others less severely attacked struggle upwards, but their tops are thin, many flowers drop prematurely and the set of fruit is poor. Wilting of the plants now occurs early in the season and it may be severe by the time the plants are forming their third or fourth trusses. Badly diseased plants do not recover their turgidity at night, and even in dull cloudy weather their foliage is still flaccid and drooping in the early morning, Fig. 12, Plate VI. When such plants are dug up they are found to have no root development worth mentioning, the roots having been attacked and destroyed as fast as they appeared, Fig. 14, Plate VII. This condition may arise in the season following that in which the disease first became noticeable. As the summer goes on the disease becomes well established on the other plants, this is shown by the number which wilt during bright weather, develop spindly tops and fail to set most of the flowers on the upper trusses. The early stages of attack are very often overlooked and frequently the disease becomes

intense before the grower realizes its presence. Owing to the rapid progress of the fungus through the soil of a tomato house, it is not unusual for the yield to drop by one-third within twelve months.

Secondary effects ascribed to the presence of *Colletotrichum atramentarium* by Bewley and White (3) are blotchiness of the fruit and development of an amethyst colour in the stem wood of affected plants near ground level. Although the last mentioned is common enough in stems of badly diseased plants, neither symptom appears to be a constant feature of the disease.

In addition to being parasitic on the roots of various plants, the fungus continues to live saprophytically on the decaying roots and on old strawy material introduced into the soil with farmyard manure. Besides spreading direct in this manner, the sclerotia may give rise to fructifications which also serve to propagate the disease. Under suitable conditions of temperature and moisture, and especially when flooding of the house is carried out after the soil has been dry for some time, as is usual after the dormant season, the sclerotia form acervuli. The acervuli are little pockets crowded with short conidiophores bearing conidia. The conidia may be produced in such enormous numbers as to form a gelatinous layer amongst the setae and practically cover the surface of the sclerotium. When mature, the conidia are easily washed away by water, and their dissemination by this agent probably accounts for the rapid spread of the disease through the soil.

Bewley (2) had some evidence that the fungus could be introduced into tomato houses by means of stable manure. This source was not investigated by the present writer, but the introduction of the disease into some tomato houses in the vicinity of Dublin has been traced directly to infection present on the roots of grasses in mountain loam. The latter is obtained from the granite hills in the neighbourhood and is sold for potting purposes. It is also used to some extent for mixing with soil in tomato houses after they have been under cultivation for a few years. Any beneficial effect due to the presence of such mountain loam appears to be of a mere physical nature,

as it is naturally lacking in plant nutrients and particularly in available phosphates.

CONTROL. When the disease first appears during the growing season, conservation of the water requirements of the plants should be aimed at. Shading the house and mulching the soil are both effective in this respect ; the former reduces transpiration to a minimum and the latter retards evaporation from the soil surface. The mulch should be put on two to three inches in depth, and it may consist of good rich loam, peat, farmyard manure, or a mixture of these ingredients. The use of peat in the mulch is strongly recommended, as it induces the development of new roots from the base of the stem, and these partially tend to replace those destroyed by the fungus. Attention to these points early in the season will frequently enable the grower to ripen most of a crop successfully, which otherwise would be lost owing to the ravages of the fungus. At the end of the season all plants should be lifted with a fork and as many roots as possible removed from the soil, all plant remains being burnt. This procedure eliminates enormous quantities of diseased material from the soil, but it is only a preliminary one to further treatment. Complete control of the disease can only be attained either by the removal and replacement of infected soil with fresh soil free from the organism, or by sterilization.

(*i*) REMOVAL AND REPLACEMENT OF INFECTED SOIL. Where houses are relatively small and where plenty of good rich old pasture is available, this method is cheap and effective if thoroughly carried out. The top fifteen to eighteen inches of soil is removed from the house systematically and replaced by fresh loam brought in from the pasture, care being taken to prevent any contamination of the fresh soil during the operation. Complete removal of all infected soil is essential, and the addition of fresh loam to infected soil cannot be recommended. At the best the latter is only a palliative measure, and the disease generally occurs with increased virulence the following year. Soil from diseased houses may be used as a top dressing for grassland but on no account should it be

applied to the vegetable garden where potatoes are likely to be planted.

(*ii*) STERILIZATION OF SOIL BY FORMALDEHYDE. One gallon of forty per cent. formaldehyde (usually sold under the trade name of formalin) is added to forty-nine gallons of water making a two per cent. solution. This is watered in with a watering can applying it at the rate of fifty gallons to every ten to eighteen square yards of soil. The soil is then dug over and the surface covered with tarpaulins or sacks for forty-eight hours. The materials used for covering the soil after digging should have been thoroughly wetted with the formaldehyde solution. Where the soil is heavy the greater quantity (i.e. fifty gallons to ten square yards) is used, but on lighter soil the smaller quantity is usually sufficient. The treament with formaldehyde should be carried out three to four weeks before planting. When being treated, the house should be marked out in sections corresponding to ten or eighteen square yards each, and as each section is treated with the solution it should be dug over and covered immediately. In houses where bastard trenching is done, very thorough treatment with formaldehyde can be carried out by applying fifty gallons of the solution to every ten square yards of soil area, treating both the lower and top spits respectively before turning each over, and then covering as advised above. Covering the soil after treatment and digging is essential if the full effects are to be obtained from the gas liberated by the formaldehyde.

(*iii*) SOIL STERILIZATION BY HEAT. As large quantities of soil have to be treated in infected houses steaming is the method generally employed. Steam under pressure is introduced into the soil to the requisite depth until a uniform temperature of 210–212°F. is registered, and this temperature is maintained for a sufficient length of time to destroy any parasitic organisms present. The cost of steam sterilization of soil in tomato houses is far higher than that of chemical treatment but it is a much more efficient method. The results are more lasting and besides, both the physical condition and the fertility of the soil are vastly improved by steaming. Where moderately

FIG. 12. HEALTHY TOMATO PLANT ON LEFT, TURGID: PLANT ON RIGHT, FOLIAGE FLACCID AND DROOPING DUE TO ATTACK OF TOMATO ROOT ROT, *Colletotrichum atramentarium*. (PHOTOGRAPHED 9 A.M.) (*Reproduced by permission from "Journal, Department of Agriculture, Eire," Vol. xxxix*).

PLATE VII

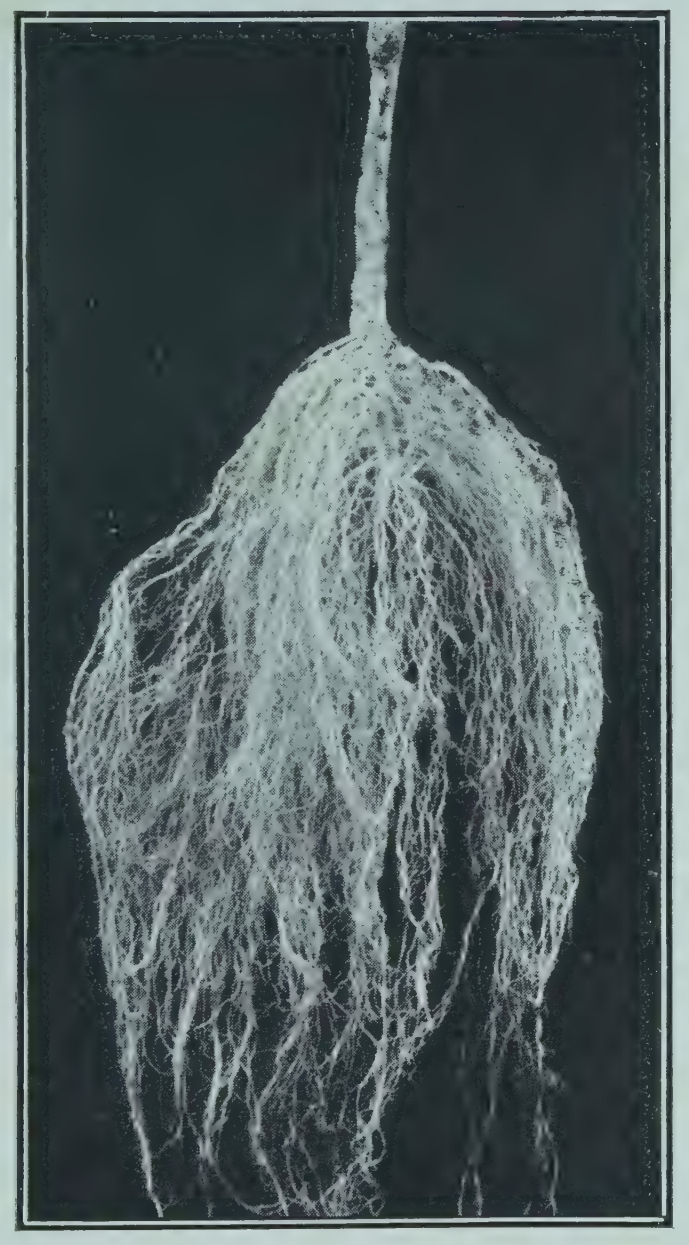

FIG. 13

FIG. 14

FIG. 13. ROOT SYSTEM OF HEALTHY PLANT IN FIG. 12. FIG. 14. ROOT SYSTEM OF DISEASED PLANT IN FIG. 12, PLATE VI. (*Figs.* 13 *and* 14 *reproduced by permission from "Journal, Department of Agriculture, Eire," Vol. xxxix.*)

rich soils are steamed, complex organic bodies are broken down into simpler forms and plant food rendered easily available ; hence, for this reason it is usual to withhold nitrogenous fertilizers in the early part of the next growing season, otherwise the plants make too soft growth. Steam sterilization has proved to be so profitable that many commercial growers have installed permanent apparatus for this purpose. Various methods of steaming soil have been evolved, but as the procedure varies considerably, growers who are thinking of steam sterilization are recommended to consult, Bulletin No. 22, *Practical Soil Sterilization*, issued by The Ministry of Agriculture and Fisheries, London.

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2. Bewley, W. F.—Ibid., *Eighth Annual Report*, pp. 34-45, 1922.
3. Bewley, W. F. and White, H. L.—Some nutritional disorders of the tomato. *Annals of Applied Biology*, Vol. xiii, pp. 323-338, 1926.

VERTICILLIUM WILT

Verticillium albo-atrum REINKE & BERTH.

The fungus *Verticillium albo-atrum* was first described and named by Reinke and Berthold in 1879 (5), the organism having been found in potato plants associated with the disease then known as Kräuselkrankheit (Curl Disease). Almost thirty years elapsed before much interest was taken in the fungus, when, towards the end of the first decade of the present century several workers on the continent again reported *Verticillium* as present in diseased potato plants in Germany. At the same time there was much confusion on the question of identity of the organism involved in the pathological condition. This was chiefly owing to the inability of the different investigators to segregate *Verticillium* and its effects on the host from other maladies present, including species of *Fusarium* and the virus disease now recognized as Leaf Roll.

Pethybridge (7) found the fungus in diseased potato plants early in his investigations on potato diseases in Ireland, and we are indebted to him for the first lucid account in English of Verticillium Wilt in this host (8). In this last publication he not only describes the symptoms of the disease clearly, but he differentiates between them and those produced by other maladies of the potato plant.

From 1910 onwards, reports on the susceptibility of other plants to *Verticillium* became increasingly frequent, and by 1931, when Rudolph's paper appeared (6), *Verticillium albo-atrum* (or closely related strains of *Verticillium*) had been reported as causing disease in over one hundred and twenty species of plants, included in thirty-five widely unrelated families and eighteen orders.

The first mention in literature of the susceptibility of tomato plants to *Verticillium* appears to be that by Jagger and Stewart in 1918 (3). Since then, wilt in tomato plants due to this fungus has been reported many times from various countries throughout the world, the disease occurring both in the open and under glass. It is more prevalent in tomato plants grown in glasshouses than in those grown out-of-doors, and under the former conditions it was the subject of very thorough investigation by Bewley (1).

Verticillium Wilt, or "Sleepy" Disease as it is sometimes called, is quite common in tomato plants; however, it is the writer's experience that many growers often mistake attacks of the Root Rot fungus (*Colletotrichum atramentarium*) for the *Verticillium* disease. This confusion arises from the fact that in both diseases the foliage wilts during the daytime and more or less recovers its turgidity at night, or in very dull weather. Beyond this point of similarity in symptoms there is little resemblance between the two diseases, and an examination of the plant's root system is generally sufficient to determine the presence or absence of Root Rot.

OCCURRENCE OF THE DISEASE. Verticillium Wilt is liable to occur on all types of soil, but it is usually worse on those of a clayey nature than on warmer sandy soils. Few

or many plants in a house may be attacked, and they may occur scattered indiscriminately throughout the house or be restricted to fairly well defined areas. Frequently the disease is noticed in a few plants at first and it becomes progressively worse in succeeding years.

The introduction of the fungus into glasshouses may take place in several ways. One case investigated in Ireland was due to buying in plants which were already infected, although no symptoms of disease were apparent at the time of the transaction. The fungus *Verticillium albo-atrum* is very sensitive to high temperatures. When young plants are raised in propagating houses with relatively high temperatures, even though infection takes place symptoms of the disease are retarded from developing. When such infected plants are set out under cooler conditions the disease rapidly manifests itself. The particular case just referred to was most unfortunate as the introduction of the infected plants took place into a glasshouse where the soil had just undergone sterilization. Under such conditions the fungus is known to spread rapidly through the soil owing to the absence of competitive organisms.

The normal occurrence of *Verticillium* in tomato houses is for a few plants to become infected at first, and from such the disease then spreads ; but sudden virulent outbreaks of this wilt are not unknown in newly erected glasshouses. An account of such outbreaks has been published in the *Gardener's Chronicle*, McKay (4). This account describes serious loss in the first year's cropping where houses were erected on the site of an old rhubarb plantation. The fungus *Verticillium* can be quite common in rhubarb roots without unduly asserting itself. Therefore, the introduction of rhubarb " stools " into tomato or propagating houses for forcing purposes should be avoided, as *Verticillium* may be introduced unwittingly in such cases through pieces of the root-stock which may become broken off and get into the soil.

SYMPTOMS OF VERTICILLIUM WILT ON TOMATO PLANTS. When very young plants are attacked, the internodes of their stems fail to elongate normally and the

plants remain stunted in growth. Attention is usually drawn to the disease by the rather sudden wilting of the lower leaves of infected plants, Fig. 18, Plate IX. The leaflets on the basal petioles droop, their margins roll in towards the midrib, yellow blotches appear on them and they feel somewhat crisp; finally they wither and dry up. Meanwhile, the upper foliage collapses but remains hanging on the plant, which eventually dies, Fig. 19, Plate IX. The rapidity with which death ensues depends mainly on the environmental conditions, and where these favour the disease little or no recovery to a turgid state occurs at night.

On cutting open the stem of a wilted plant in the region of the soil level, the woody, sap-conducting vessels, instead of being white as in healthy plants, are seen to be stained brown. This discoloration can be traced down into the roots, where it originated, and frequently it extends upwards in the stem for some considerable distance.

An external examination of the washed roots of plants in the early stages of this disease, or which are in process of being killed by it, does not as a rule reveal anything amiss. The roots of such plants appear white and healthy looking to the naked eye, Fig. 22, Plate XI. This seemingly healthy appearance of the roots immediately eliminates the question of the Root Rot disease. Nevertheless, microscopical examination of these roots and also of the lower part of the stem shows the wood vessels to be full of mycelium. The only certain means of diagnosing the disease is by finding the fungus *Verticillium albo-atrum* in the wood vessels, or by getting it to grow out from the cut ends of the vessels when pieces of stems or roots are incubated in a moist chamber at 18–20°C., as in Fig. 23, Plate XI. It is this fungus in the sap conducting channels which causes the wilting and premature death of the plants. Its presence interferes with the ascent of water and food materials, and in addition, it produces a toxic substance which stains the wood vessels and helps to bring about the death of the leaves.

In the case of plants which have been dead for some time from the disease and are under damp conditions, a whitish fungal growth may be found at the base of the stems, or

FIG. 15

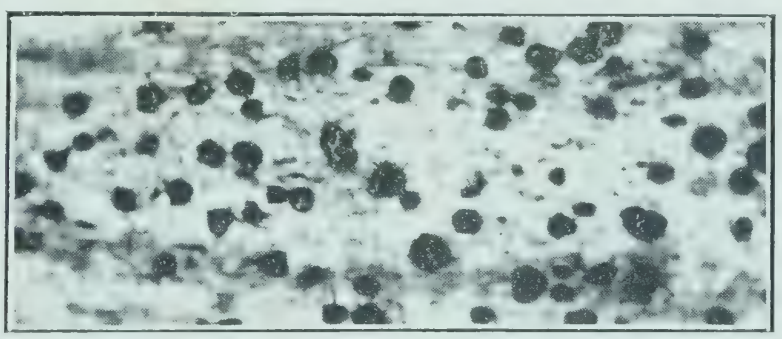

FIG. 16

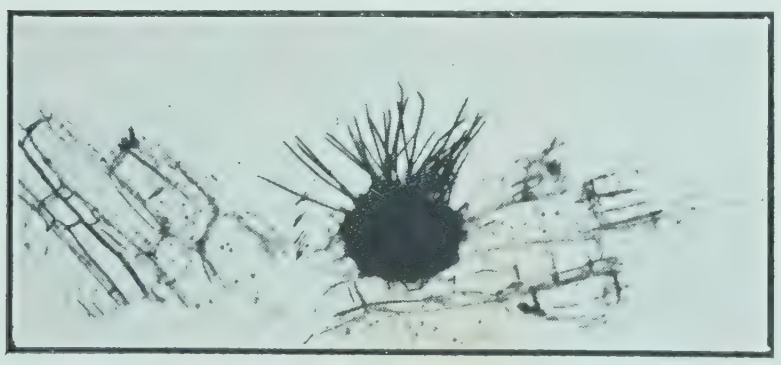

FIG. 17

FIG. 15. TOMATO ROOT ROT. CHARACTERISTIC SYMPTOMS OF ATTACK BY *Colletotrichum atramentarium.*

FIG. 16. PHOTOMICROGRAPH SHOWING SCLEROTIA OF *Colletotrichum atramentarium* ON DISEASED CORTEX. X 30.

FIG. 17. PHOTOMICROGRAPH OF SINGLE SCLEROTIUM OF *Colletotrichum atramentarium* WITH SETAE. X 52. (*Figs.* 15, 16 *and* 17 *reproduced by permission from "Journal, Department of Agriculture, Eire," Vol. xxxix.*)

FIG. 18

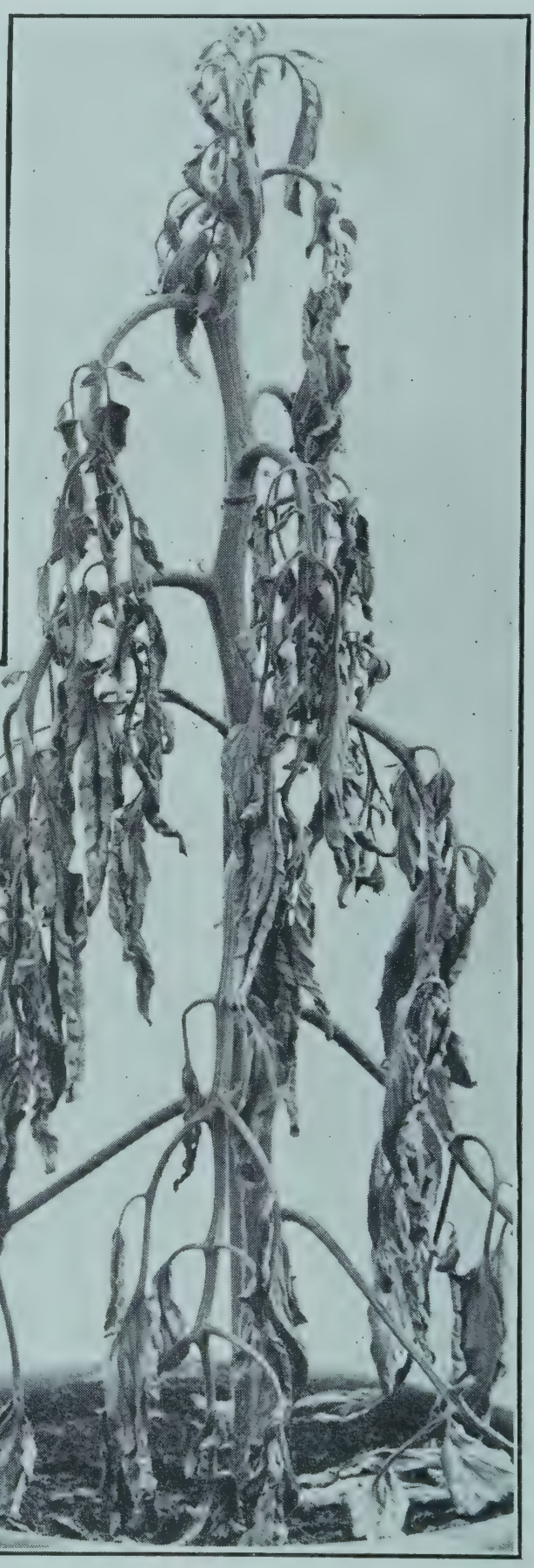

FIG. 19

FIG. 18. VERTICILLIUM WILT. EARLY STAGES OF THE DISEASE CAUSED BY *Verticillium albo-atrum* SHOWING ROLLING AND WILTING OF THE LOWER LEAVES. *Photo.* 22 *May*, 1941.

FIG. 19. ANOTHER TOMATO PLANT SHOWING THE FINAL STAGE OF VERTICILLIUM WILT.

PLATE X

FIG. 21

FIG. 20

FIG. 20. THE SAME PLANT AS THAT IN FIG. 18, PLATE IX, SHOWING RECOVERY FROM WILT WHEN THE PLANT WAS KEPT AT A HIGH TEMPERATURE. *Photo.* 23 *June*, 1941.

FIG. 21. REAPPEARANCE OF WILT WHEN THE SAME PLANT WAS TRANSFERRED AND KEPT FOR SOME TIME IN COOL HOUSE. *Photo.* 15 *July*, 1941.

PLATE XI

FIG. 23

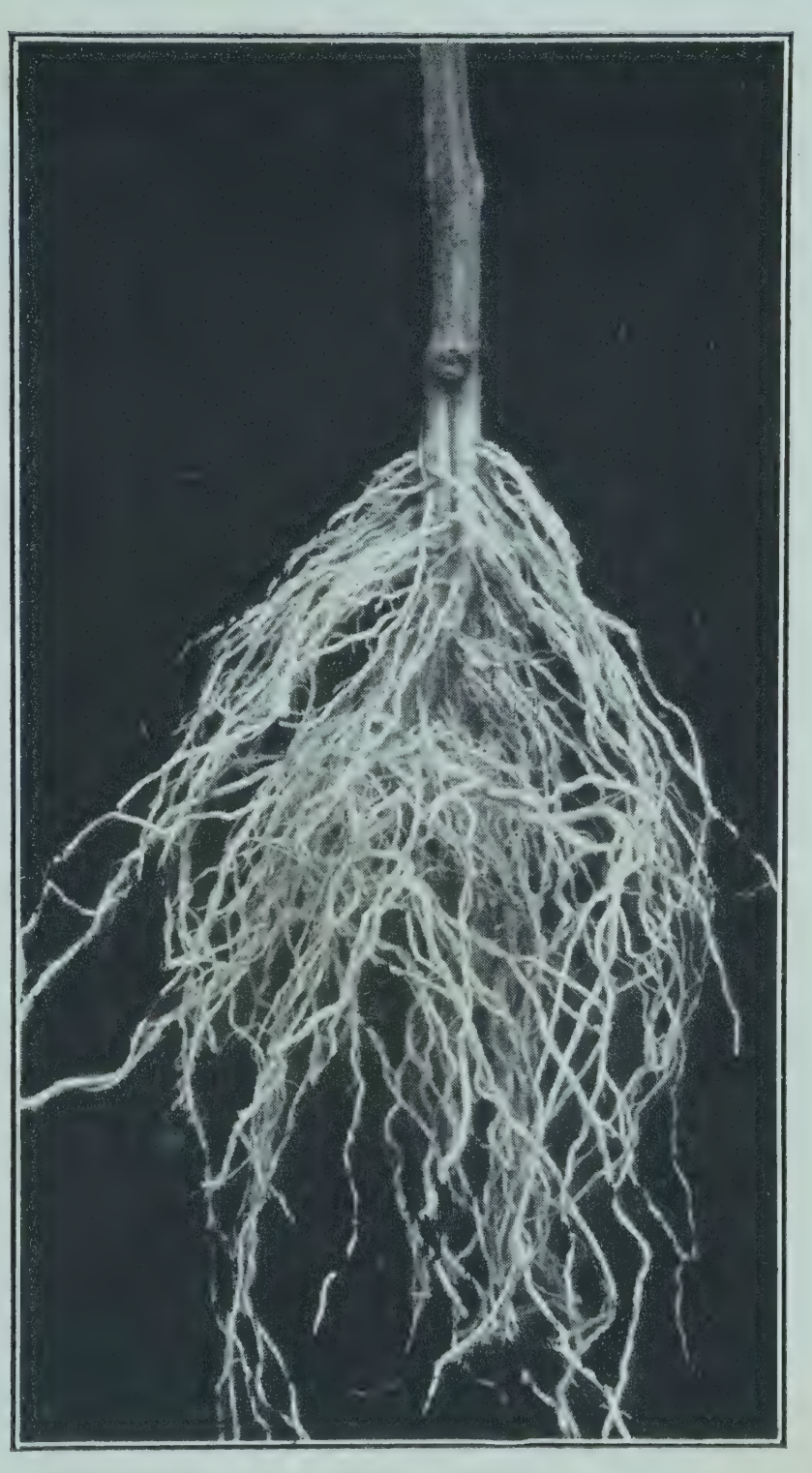

FIG. 22

FIG. 22. GENERAL HEALTHY APPEARANCE OF ROOT SYSTEM OF PLANT IN FIG. 21, PLATE X, BEFORE PLANT WAS KILLED OUTRIGHT BY *Verticillium albo-atrum.*

FIG. 23. THE FUNGUS *Verticillium albo-atrum* GROWING OUT OF THE WOOD VESSELS ON CUT END OF STEM OF PLANT AT GROUND LEVEL AFTER INCUBATION AT 20°C. PART OF SAME STEM AS THAT SHOWN IN FIG. 22. X 63.

occasionally on the roots which become somewhat discoloured after the plant is dead. This superficial growth consists mainly of fructifications of the fungus, the fertile branches being produced in whorls and bearing spores at their free ends. These spores serve to spread the disease and are distributed by wind and other agencies when they are produced above ground and by water when they are formed on roots in the soil. The spores on germination in the soil give rise to hyphae, and infection follows from hyphae coming into contact with the roots of susceptible plants. Once inside the root the fungus makes its way to the wood vessels of the stem. These become more or less choked, and soon after their invasion disease symptoms develop on the overground parts of the plant.

Under drier conditions the mycelium in tissues of dead plants forms sclerotia, or some strains of the fungus forms strands of dark, thick-walled cells. Both the sclerotia and this resting mycelium are set free in the soil on the decay of the host : these bodies enable the fungus to survive over the winter or through a period of unfavourable conditions. When the factors of moisture and temperature again become suitable these resting bodies of the fungus resume growth, and their cells give rise to ordinary hyphae in the soil. Infection follows as in the case of hyphae derived from spores.

TEMPERATURE RELATIONS. Bewley (1) has shown that *Verticillium albo-atrum* is a fungus which thrives at relatively low or moderate temperatures, and for this reason the disease is worse in spring and autumn than at the height of summer. Above 77°F. practically no wilt of infected plants occurs, and when wilted plants in the early stages of the disease are removed to a constant temperature of 77°F. they recover, the lower leaves drying up, Fig, 20, Plate X. It must be remembered, however, that while apparent recovery takes place under such conditions, wilt symptoms will reappear, sooner or later, when the temperature is allowed to drop for any length of time, Fig. 21, Plate X.

CONTROL. If, as frequently happens, only an occasional plant is diseased, these should be carefully dug up and destroyed,

taking care to remove all roots and the soil surrounding the infected plants. These measures, if properly attended to, will often prevent *Verticillium* becoming established in a glasshouse. In this connexion, it cannot be too strongly emphasized that all roots of diseased plants must be removed. If this is not done, more infection may follow the violent removal of wilted plants than would occur if the diseased plants were left to succumb naturally. The available evidence is, that the roots of a diseased plant do not act as a source of infection to neighbouring plants until the fungus emerges from the vascular cylinder, which it does not do until the roots are moribund. Discussing this question of increased infection following removal of diseased plants, Garrett (2) has suggested that the violent removal of wilted plants hastens the death of those portions of infected roots left behind in the soil, with the result that the fungus emerges from the vascular cylinder of such roots earlier that it would have done if the plants were left undisturbed.

Where many plants are wilting and *Verticillium* diagnosed as the cause other measures of control will have to be employed. The grower's first aim in such cases is to get the diseased plants to continue growth and to ripen as much of their fruit as possible. Fortunately this can be done in the majority of cases. As already indicated, high temperatures provide a ready means for combating this disease, and as soon as this wilt is noticed developing the temperature of the house should be raised to 77°F. This may be done by a little artificial heat and by closing the ventilators for two to four hours in the middle of the day. To get the best results attention should be paid to the following details. Suitable shading of the house should be carried out, by whitewashing, painting the glass or by screens ; this tends to reduce transpiration. The plants may be kept turgid by overhead sprinkling, and only the minimum amount of water necessary to keep the plants growing should be given to the soil, which should be kept rather on the dry side, as it has been found that flooding favours the development of the disease. Fresh root formation should be induced at the base of the plant by mulching the soil, as already recommended for the Root Rot disease.

The foregoing are only temporary measures to enable the grower to ripen his crop, and at the end of the season all plants should be dug up and burnt. The soil should then be sterilized either by steaming or by chemical treatment with formaldehyde.

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FUSARIUM WILT

Fusarium bulbigenum cooke & massee var. *Lycopersici*

" Sleepy " Disease of tomato plants resulting from attacks of *Fusarium* species is relatively rare in this country, especially when compared with wilting caused by *Verticillium albo-atrum* or *Colletotrichum atramentarium*. The chief reason for this is that *Fusarium bulbigenum* var. *Lycopersici*, which is the species most likely to occur, requires a higher temperature for its development than either of the other two fungi. Bewley points out that little development of Fusarium Wilt takes place below a soil temperature of 29°C. (84.2°F.). This maximum is seldom reached in Ireland, and Fusarium Wilt only appears during

the height of summer or in very warm years : generally speaking it is associated with sandy soils rather than with clay soils.

SYMPTOMS OF FUSARIUM WILT. Infection takes place through the roots, and after the fungus penetrates their vascular bundles it soon makes its way to the wood vessels of the stem. These quickly become blocked when temperature conditions are favourable for the growth of the parasite, and a wilt of the top follows which is included under the common term " Sleepy " Disease. The symptoms of Fusarium Wilt are rather similar to those caused by *Verticillium albo-atrum*, and, as in the latter case, incubation and a microscopical examination of diseased plants are often necessary before the fungus can be identified.

At the same time, there are a few macroscopical features of this disease which help in the recognition of *Fusarium* infection. The fungus affects the roots considerably, with the result that the root system is often poorly developed, and in some cases it is almost destroyed. Furthermore, when the main root is split, the woody tissue therein is usually found discoloured, being quite dark or nearly black in colour. The small lateral roots also show a black rot. Where plants have been killed by *Fusarium*, a superficial growth of the fungus, somewhat pink in colour, occasionally is found around the base of the stem or on the roots.

On incubation of infected stems and roots at temperatures between 25° and 30°C., the fungus grows out from the cut ends of the vessels, and soon after its appearance the characteristic, sickle-shaped, septate spores develop, thus completing the diagnosis. In the case of this wilt, under favourable environmental conditions fructifications are produced in large numbers and contaminate the soil, the fungus being a soil organism.

CONTROL. If only a few plants are found diseased, as is often the case, complete removal of them along with all soil in contact with their roots is all that is generally required. This may be supplemented by a heavy dressing of quicklime to the soil, a procedure which has been proved to be detrimental to *Fusarium bulbigenum* var. *Lycopersici*. Where infection is prevalent, then the temperature of the house should be kept

low by shading and ventilation, and a mulch should be given around the base of the plants to encourage new root formation. At the end of the growing season all plant remains should be burnt and the soil treated by one of the methods already recommended for ground sick with the Root Rot organism *Colletotrichum atramentarium*, pages 23-25.

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STEM CANKER

Didymella Lycopersici KLEB.

ALTHOUGH this fungus attacks cucumbers and strawberry plants it is through the destruction of tomato stems by means of a canker that it is best known. Its ravages on tomatoes were exceptionally severe in Great Britain in the early part of the present century, but its attacks gradually diminished towards the end of the second decade, at which time the disease was only considered of minor importance. A period of quiescence then apparently set in, and though occasional infected plants occurred little notice was taken of the disease until interest was revived in it by numerous rather virulent outbreaks of canker in the years 1941-1944. These outbreaks caused serious loss to growers, and they also demonstrated the difficulty of controlling the disease by ordinary methods of spraying or soil sterilization. The disease is of fairly common occurrence in Ireland, both on plants under glass and on those grown outside.

SYMPTOMS. Plants of all ages may be infected, though the disease is seldom seen until after the plants have been set out in their permanent quarters. All the above ground parts are liable to infection, but the attack on the stem is the most serious as it is soon girdled by the fungus and killed. The attack generally occurs at the base of the plant, the first sign of disease appearing as a dark brown lesion just above soil

level. The skin over the affected part varies in colour from ashy-grey to greyish-brown or buff, the diseased tissues shrink and the stem becomes somewhat constricted in the region of invasion. The diseased area takes on a felty appearance and it has a tendency to split open by a longitudinal crack, Fig. 25, Plate XII. The dirty grey, discoloured surface of the lesion appears rough and pimply owing to the development within the tissues of pycnidia. These are the fructifications of the fungus, and they are just visible to the naked eye or with the aid of a pocket lens, Fig. 25, Plate XII. Each fructification consists of a small flask-shaped body termed the pycnidium, and which opens to the surface of the host by a mouth or pore, Fig. 26, Plate XII. Under moist conditions the spores exude out through the openings and may be present as flesh coloured tendrils or slimy masses. Meanwhile the cortex decays, splits open, and eventually the woody cylinder of the stem becomes exposed, resulting in a canker, Fig. 24, Plate XII. Girdling of the stem by now is usually complete and the plant wilts and dies. The lesions at soil level vary in size from one half to three inches longitudinally. The pith and vascular strands become somewhat discoloured in the region of attack, and the upper margin between diseased and healthy tissue is often marked by a ridge. The relatively small size of the lesion accompanied by complete girdling of the stem, the rough, ashy-grey appearance of the infected cortex, and the open nature of the canker, all serve to distinguish attacks of *Didymella Lycopersici* from rot due to *Botrytis cinerea*.

The disease on the foliage is seldom severe enough to attract the grower's attention, but secondary lesions occurring higher up the stem may be prevalent, infection generally developing at the nodes. In some cases the disease may start in the leaf stalk and work back into the stem. As a rule, secondary lesions are smaller longitudinally than those at soil level, but they also rapidly encircle the stem at the point of attack, giving it a pinched appearance. These attacks on the upper parts of stems arise mainly from spores produced on primary lesions at soil level, the spores being scattered by ordinary cultural practices.

PLATE XII

FIG. 24

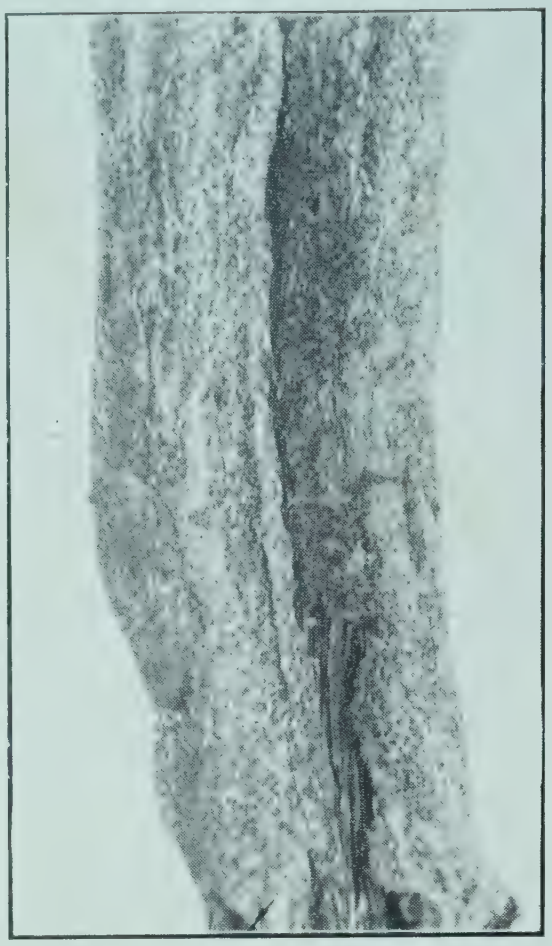

FIG. 25

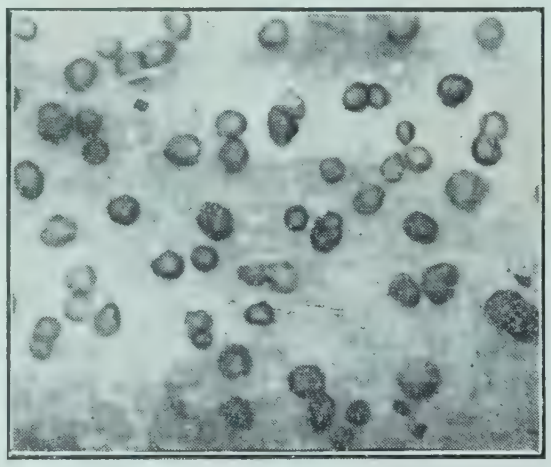

FIG. 26

FIG. 24. STEM CANKER, *Didymella Lycopersici.* TYPICAL APPEARANCE OF THIS DISEASE ABOVE SOIL LEVEL.

FIG. 25. EARLY STAGE OF STEM CANKER SHOWING SPLITTING OF CORTEX, GENERAL FELT-LIKE APPEARANCE AND NUMEROUS PYCNIDIA OF THE FUNGUS *Didymella Lycopersici.*

FIG. 26. LENS VIEW OF PIECE OF CORTEX FROM DISEASED PORTION IN FIG. 25, SHOWING SURFACE VIEW OF THE PYCNIDIA.

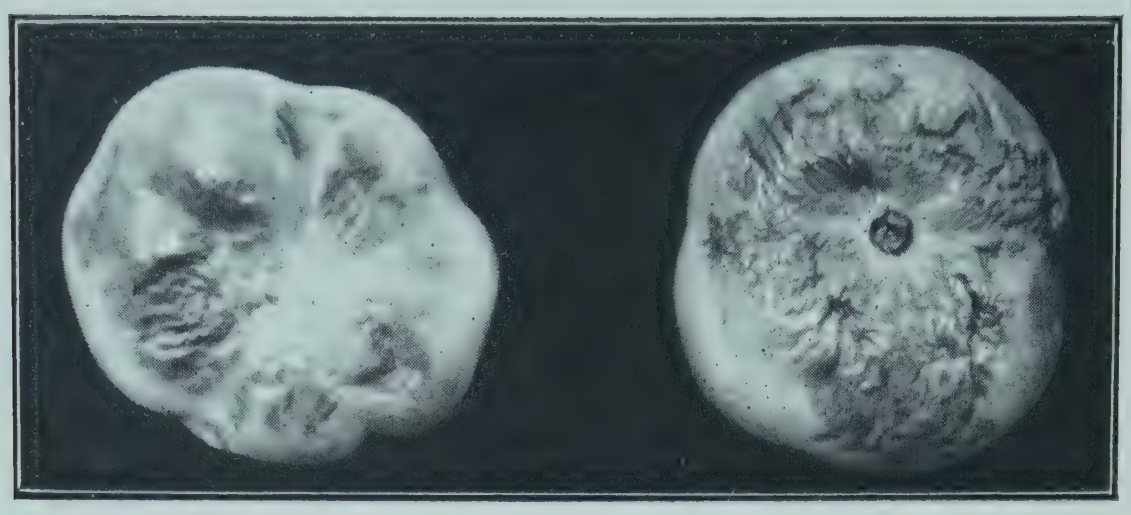

FIG. 27

FIG. 28

FIG. 27. TYPICAL APPEARANCE OF TOMATOES ATTACKED BY THE POTATO BLIGHT FUNGUS, *Phytophthora infestans*. FIG. 28. *Phytophthora infestans* FRUCTIFYING ON TOMATOES UNDER DAMP HUMID CONDITIONS.

Fruit infection is rare under glasshouse conditions whereas it may be common outside. In nearly all cases the attack on the fruit takes place at the stem-end. At first the diseased part appears slightly discoloured and is somewhat spongy. The infection spreads rapidly and the skin soon darkens, forming a black crust on which numerous pycnidia develop, and the fruit falls to the ground. Infection of the seed also takes place and it turns brown or black.

The chief spore stage of *Didymella Lycopersici* is the pycnospore, but Hickman (1) has recorded a second spore form on plants grown outside. This is the ascospore stage which develops in perithecia formed on diseased plants. At present it seems to be of rather unusual occurrence, and the part played by it in causing primary infection is not quite clear. All sources of infection do not yet appear to be fully known, and it is often difficult to account for outbreaks of the disease. The statement has been made repeatedly that this fungus can overwinter in the soil, but no information is available as to the form in which overwintering occurs, whether as fungus mycelium or as spores. Once an outbreak of *Didymella Lycopersici* occurs in a glasshouse the fungus is difficult to eradicate. Frequently the disease has broken out virulently in houses where the soil has been sterilized. A very likely explanation of such outbreaks is forthcoming from Ogilvie's experiments (3). He showed that infected seed sown in sterilized soil gave rise to seedlings infected with *Didymella Lycopersici*. Under humid conditions the tips of the cotyledons shrivelled and appeared to have been infected directly from the seed, which was carried above the ground. Badly diseased seedlings die off, but they infect the soil, thus leading to Stem Canker of older plants. Furthermore, as a result of his experiments with diseased seed, Ogilvie concluded that in some cases no symptoms may be visible on the seedlings but infection of the soil may take place directly from the diseased seed, and this may lead to prevalent infection of more mature plants.

CONTROL. Measures recommended for the control of the disease may be regarded as only tentative until a more thorough knowledge of all sources of infection is available.

The system of tying up plants appears to influence the number of infections at ground level. Where upright cords are tied to a wire stretched along the surface of the soil or to long wire pegs driven into the earth, the number of diseased plants never seems to be so great as where the cords are tied direct to the base of the stems. The last method of tying up tomato plants became more or less a general practice during the war period because of the scarcity of wire. All diseased plants should be removed and burnt as soon as they are noticed. A high degree of atmospheric humidity is requisite for infection, therefore, the house should be kept as dry as possible. At the end of the season all tomato refuse should be burnt and neither dug into the soil nor thrown on the manure or compost heap. In no case should seed be saved from diseased plants. Wire supports, canes and strings from houses where the disease has occurred are known to act as sources of infection to the succeeding crop. Presumably in these cases the fungus survives in the form of pycnospores. These have been shown to retain their viability in some cases for as long as two years, Liesau (2). Bamboo canes, supports and strings should be sterilized either by steeping in a strong formalin solution (three to five per cent.) for half an hour or well sprayed with the same fungicide.

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BLIGHT OF TOMATOES

Phytophthora infestans (MONT.) DE BARY

It is well known that the Potato Blight fungus *Phytophthora infestans* readily attacks tomato plants, this host being only slightly more resistant to the disease than the potato. A number of investigators have maintained that the strains of *Phytophthora infestans* occurring on tomatoes are really specialized forms somewhat different from those found on potato plants. Whatever truth there is in the question of definite strains of this organism, there is no doubt about the ability of the ordinary potato strain to pass readily to the tomato. This has been proved experimentally time and again, and confirmation of it is continually forthcoming from field observations which show that wherever tomatoes are planted near to potatoes, they invariably become blighted soon after the disease appears on the potatoes. Others planted away from potatoes remain free from Blight for a much longer period or until the disease has become general over the potato crop.

This disease is rarely of any consequence on tomatoes grown in glasshouses, unless these are very leaky or plots of blighted potatoes are growing adjacent, when more or less of it may develop. Blight, however, is common on outdoor tomatoes, the attack being similar to what it is on the potato crop.

SYMPTOMS. Black purplish lesions appear on the foliage and stems, the diseased areas become somewhat water-soaked in appearance, and if the plants are under very damp conditions a slight growth of the fungus develops on the undersides of diseased leaves around the margins of the lesions ; infected areas on the stems may be several inches in length. Finally, in bad attacks the foliage turns completely black and the plants die, presenting an appearance not unlike frost damage.

Such severe ravages of the disease are seldom seen on outdoor tomato plants in Ireland even in spite of the prevalence of Potato Blight. Various factors contribute to prevent the disease becoming virulent on tomato foliage in this country, and amongst

these the following may be mentioned : outdoor tomatoes are only cultivated on a very small scale, a few plants being grown in the most favoured localities ; even when thus grown, the plants are well spaced and the rows far apart, and disbudding of laterals and defoliation of the basal leaves further tend to keep the foliage dry : moreover, the rolling of the foliage of such plants apparently toughens the leaves and makes them somewhat resistant to the disease.

Notwithstanding, the attack of Blight on the fruit is often out of all proportion to that observed on the leaves, and in many years much of the crop is spoiled, and especially so if diseased potatoes are in its neighbourhood. Potato berries are about the most susceptible part of the potato plant to Blight infection and the same is true of tomato fruits, these being susceptible to attack throughout all stages of their development. The majority of diseased fruit become infected at the heel end ; air borne spores alight in the basal cavity and infection is evidently favoured by moisture held around the calyx. From the time infection occurs until the disease becomes visible takes about five or six days. The first sign of attack on the fruit is a slight darkish discoloration on the skin, the spot being without any definite margin. The skin over the infected area soon turns brown and slight depressions occur in it. As the disease develops the surface of the lesion becomes wrinkled or slightly corrugated, Fig. 27, Plate XIII. This is owing to shrinkage of the underlying diseased tissues, the fungus invading and destroying the central axis of the fruit. The infected tissues are seen to be reddish or rusty brown in colour when diseased fruit is cut open. The rate of shrinkage and decay of tomatoes by *Phytophthora infestans* depends upon environmental factors, and diseased specimens are usually devoid of any external growth, Fig. 27, Plate XIII, but if climatic conditions are very moist a sparse development of the fungus occurs on the surface of the fruit, Fig. 28, Plate XIII.

CONTROL. Owing to the risk of Blight potato plots should be kept as far as possible from tomato houses, and under no circumstances should outdoor tomatoes be planted near potatoes.

FIG. 29

FIG. 30

FIG. 29. TOMATO STEM ATTACKED BY THE SCLEROTINIA DISEASE, *Sclerotinia sclerotiorum*.

FIG. 30. DISEASED TOMATO STEM CUT OPEN TO SHOW SCLEROTIA OF *Sclerotinia sclerotiorum* IN THE PITH CAVITY.

PLATE XV

FIG. 31

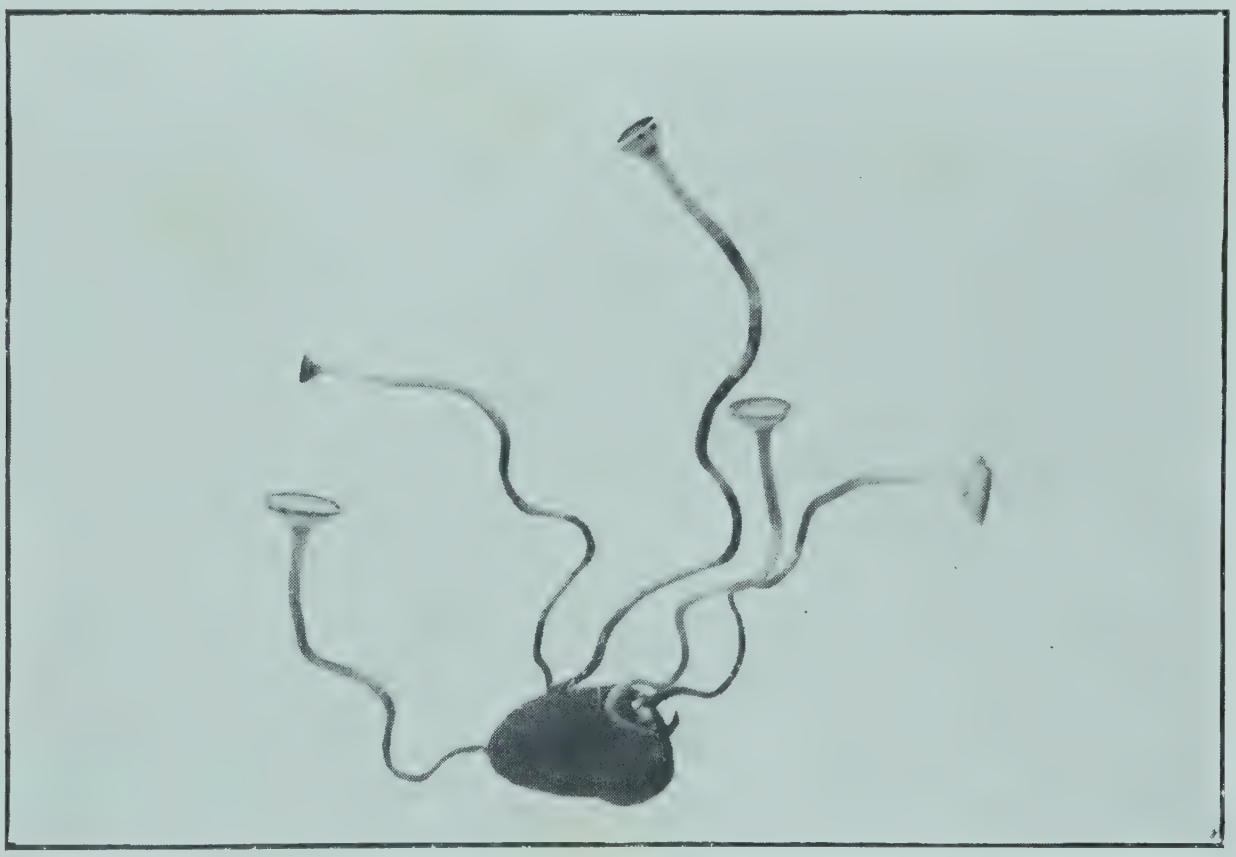

FIG. 32

FIG. 31. APOTHECIA OF *Sclerotinia sclerotiorum* ARISING FROM SCLEROTIA IN THE SOIL: NATURAL SIZE.

FIG. 32. SINGLE SCLEROTIUM OF *Sclerotinia sclerotiorum* WITH FIVE APOTHECIA: NATURAL SIZE.

If the disease appears in the glasshouse its spread can be effectively checked by increasing the temperature and keeping the atmosphere dry.

Spraying is necessary in most years for the protection of outdoor crops. Depending upon weather conditions, two, three, or more applications of spray may be required to give adequate control, the first being applied about the time Blight is becoming prevalent in surrounding potato fields. This generally happens during the month of August ; the greatest infection of tomatoes taking place during September. Fungicides containing copper give the best control of the disease. Certain proprietary substances give satisfactory control and leave no visible spray deposit on the fruit, but both the ordinary Bordeaux and Burgundy Mixtures are quite suitable for spraying tomatoes and controlling the disease. Any spray deposit remaining on the fruit when ripe can be wiped off, and no danger need be apprehended from the small amount of copper present on the skin. Either the two per cent. or the one per cent. of these mixtures may be used. The two per cent. Bordeaux Mixture contains 8 lb. copper sulphate and 4 lb. quicklime in forty gallons of water. The one per cent. mixtures contain only half these quantities of copper sulphate and quicklime (or 5 lb. washing soda) in forty gallons of water.

To obtain the best mixture the following instructions should be followed : If a two per cent. Bordeaux Mixture is required, 8 lb. of pure copper sulphate is tied up in a piece of clean sacking and suspended in water in a clean barrel. The barrel should contain thirty-five gallons of water and the copper sulphate just immersed below the surface of the water. If the copper sulphate is in crystals, these may be ground to a fine powder to enable them to dissolve more rapidly. Having prepared the copper sulphate solution (preferably overnight so that it will be ready for use when required) next prepare the milk of lime. This is done by placing the 4 lb. of freshly-burned, unslaked lime in a bucket and sprinkling it with water until it falls down into a powder. Sufficient water is then added to fill the bucket and the solution stirred up into a whitish fluid. This is then poured into

a tub and more water added to cool it and to bring the quantity up to five gallons. After being well stirred the lime solution is then strained through sacking into the copper sulphate and the mixture thoroughly stirred. The spray is then ready for use and should be applied the day it is made.

The two per cent. Burgundy Mixture is prepared in a similar manner, except that the lime is replaced by washing soda. Having dissolved the copper sulphate as described above, dissolve 10 lb. washing soda in five gallons of water in a separate vessel. Then pour the washing soda solution into the copper sulphate solution in the barrel, stirring continuously. The mixture is then ready for use and should be applied the same day.

THE SCLEROTINIA DISEASE

Sclerotinia sclerotiorum (LIB.) DE BARY

This disease is found on many herbaceous plants, the fungus attacking a wide range of hosts, and in Ireland it is only too well known by its destruction of potato stalks. Curiously enough the potato tuber itself is not attacked, but serious losses frequently occur in other fleshy roots and tubers such as carrots, parsnips, chicory, and Jerusalem artichokes.

SYMPTOMS ON TOMATO PLANTS. Attacks on this host are most liable to occur during the first summer after the house has been erected, although the disease may also develop in later years through infection arising from sclerotia introduced into the house in fresh loam. The plants are attacked at varying heights above soil level, infection usually occurring on some part of the basal two feet of the stem, causing destruction of the cortex and pith and giving the stem a frayed appearance at the point of attack, and were it not for the support given to the stem by the cord or stake it would topple over at the damaged part, Fig. 29, Plate XIV. The foliage above the point of attack wilts and it may wither completely and dry up. Under moist

PLATE XVI

FIG. 33

FIG. 34

FIG. 35

FIG. 33. ROOT SYSTEM OF TOMATO PLANT INFECTED WITH *Spongospora subterranea.*

FIG. 34. TOMATO ROOTS CANKERED THROUGHOUT THEIR ENTIRE LENGTH BY *Spongospora subterranea.*

FIG. 35. GALLS ON TOMATO ROOT DUE TO ATTACKS OF *Spongospora subterranea.* FIGS. 34 AND 35 NATURAL SIZE. NOTE DEVELOPMENT OF FIBROUS ROOTS FROM AFFECTED AREAS AND COMPARE WITH FIGS. 79 AND 80, PLATE XLI.

PLATE XVII

FIG. 36

FIG. 37

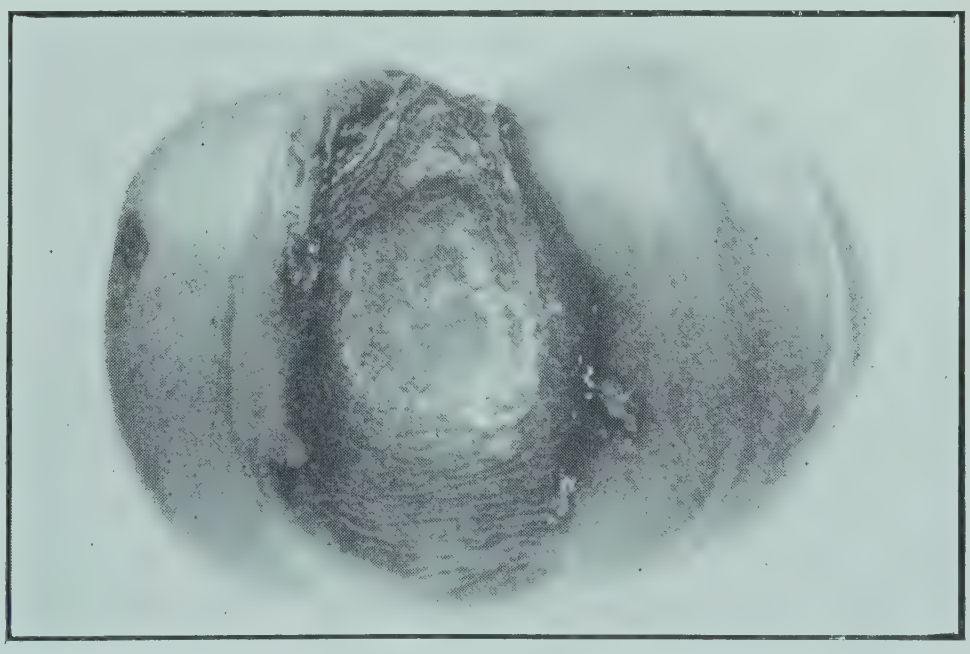

FIG. 38

FIGS. 36 AND 37. BUCKEYE ROT ON TOMATOES DUE TO ATTACKS OF *Phytophthora parasitica.*

FIG. 38. *Phoma destructiva* ON TOMATO.

conditions the fungus forms "cushions" of white mycelium on the outside of the stem and similar masses also develop in the pith cavity. As the attack progresses and food supplies in the host become depleted the outer layers of these masses of mycelium change from white to pink or brown and finally to black ; the whole structure becoming at the same time compact, firm and hard, Fig. 30, Plate XIV.

These black bodies are the sclerotia of the fungus and on the decay of the host they fall off into the soil, remaining dormant throughout the winter. In the following spring those sclerotia which happen to be near the soil surface germinate, each giving rise to one or more little stalks ; eventually each of the latter expands at its tip into a funnel—or cup-shaped apothecium, Figs. 31 and 32, Plate XV. The upper surface of the cup is packed tightly with thin walled sacks termed asci, with slender paraphyses interspersed amongst them. A single apothecium may bear more than 300,000 asci, and each ascus contains eight ascospores. These do not all reach maturity at the same time, but as they ripen, on the slightest disturbance of the apothecium the ascospores are ejected in little puffs. The discharge of spores from a single fructification may occur at intervals of a few hours and continue for about two weeks before the apothecium is finally exhausted. The ascospores are distributed by air currents to neighbouring host plants on which they germinate readily and cause infection. As a rule, the disease does not spread from plant to plant, no viable spores being produced by the fungus on its host ; and although a group of plants all near each other may be diseased this arises from their proximity to apothecia which have been discharging spores.

The foregoing is a description of the typical life cycle of this fungus, but sclerotia which are buried deeply in the soil may retain their vitality for two years at least, and occasionally when a sclerotium germinates a resulting stalk may bifurcate and produce two apothecia instead of one.

CONTROL. Tomato plants which are attacked by this disease are practically useless and should be destroyed immediately they are seen. Prompt eradication of diseased plants

prevents the formation of sclerotia and the subsequent contamination of the soil, and if this procedure is thoroughly carried out the disease is easily eliminated from tomato houses.

ROOT GALLS

Spongospora subterranea (WALLR.) LAGERH.

In addition to attacking the underground parts of the potato producing powdery scab, *Spongospora subterranea* also attacks the roots of tomato plants.* Small swellings and galls caused by this organism are not uncommon on tomato roots, although often overlooked, and occasionally infection can be severe, Fig. 33, Plate XVI. No symptoms are produced on the overground parts of the plant by this disease, and it is only at the end of the season when the plants are dug up that the swollen cankered roots attract attention. The galls vary in size from a small nodule the size of a pin's head to others over one cm. in diameter, Fig. 35, Plate XVI, and few or many may be present on the root system. In some cases whole strands of the roots may be swollen and cankered throughout their entire length, Fig. 34, Plate XVI. During the early part of the growing season these galls are at first white and smooth, but they are seldom noticed until towards the end of the summer when the plants are pulled up, the swellings then appear dark brown in colour

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* When badly cankered tomato roots are examined microscopically very often great difficulty is experienced in finding any spore balls of *Spongospora subterranea*. The disease can be easily produced on tomato roots by adding spore balls of the organism obtained from affected potato tubers, either to pots containing young tomato plants or to pots of sterilized soil into which young tomato plants are transplanted. Then a microscopic examination of the infected roots early in the growing season will demonstrate plasmodia of the organism in the host cells and also spore balls in various stages of development. Some of the severe cankering of the roots of tomatoes seems to arise from spore balls germinating rapidly *in situ*, liberating amoeba which form plasmodia, these enter adjacent cells, devour their contents, pass on to neighbouring cells repeating this process, and leaving a mass of detritus in their wake.

and rough or corky in appearance. This disease on the roots does not appear to interfere to any extent with the cropping of the plant, as even in the worst cases seen plenty of healthy feeding roots were present. Attacks on tomato roots by *Spongospora subterranea* therefore do not seem to be of much consequence, but it is desirable that the grower should recognize the galls due to this organism and be able to identify them from the much more serious swellings caused by the Root Knot Eelworm, *Heterodera marioni*. Where galls result from attacks of *Spongospora subterranea* their surface soon becomes brown and rough, but even from the badly cankered and swollen parts fine, white, healthy roots will be found developing as illustrated in Figs. 34 and 35, Plate XVI. Plenty of normal roots will also be found present alongside those infected, and individual plants may have their roots severely galled whilst those adjacent may be entirely free or show only one or two swellings.

BUCKEYE ROT

Phytophthora parasitica DASTUR.

The chief organism responsible for this disease is *Phytophthora parasitica*. Infection of the fruit arises from contaminated soil. The mycelium or its fructifications may either come into direct contact with the fruit through trusses touching the ground, or they may get splashed on the fruit through careless watering. In both cases penetration of the epidermis is quickly followed by infection. The disease is generally only present on the lowermost trusses, the moist cool conditions here favour attack and infection may spread from fruit to fruit until eventually it reaches the main stem.

SYMPTOMS. The first indication of the disease is the appearance of a greyish-green or brown water-soaked spot without any definite margin. As the infected area enlarges concentric reddish-brown circles develop on the characteristic grey areas. The lesions then resemble the eye of a large animal

and typical symptoms are well described by the common name Buckeye Rot, Figs. 36 and 37, Plate XVII. Both green and ripe fruit are liable to be attacked either under glass or outside. Owing to its frequent position on the blossom end of the fruit, as this is the point most liable to come into contact with the soil, Buckeye Rot is sometimes mistaken for Blossom End Rot. However, in its early stages of development the indefinite margin of the lesion serves to identify it: later, the gradual enlargement of the lesion, zonate markings and considerable penetration of the rot indicates the presence of a fungus. Under very humid conditions the diseased area becomes covered with a white fungal growth amongst which numerous fructifications may be found.

Phytophthora parasitica is one of the soil organisms causing Damping-off and Foot Rot. Occasionally it may also attack the stems higher up, producing greyish-green elongated lesions causing the collapse of the cortex and pith, and throwing the outside of the stem into longitudinal folds. In addition to *Phytophthora parasitica*, other damping-off organisms attacking the lower trusses in a somewhat similar manner are *Phytophthora cryptogea* and *Corticium Solani*.

CONTROL. Mulching the surface of the ground with clean straw helps to protect the fruit from infection. All trusses should be tied up out of contact with the soil. The bases of the plants should be kept well trimmed to ensure a free circulation of air and prevent moist stagnant conditions. During watering care should be taken to avoid splashing the fruit with soil. If infection is prevalent the soil may be watered with Cheshunt Compound. All infected fruit should be removed and destroyed as soon as observed. Where diseased fruit is allowed to drop to the ground, it not only acts as a source of infection to the current season's crop but it increases the contamination of the soil and provides infection for subsequent years.

REFERENCE

WILLIAMS, P. H. and ENID SHEARD.—Stem Rot of Tomato caused by *Phytophthora parasitica*. *Gardener's Chronicle*, Vol. CXIV, No. 2959, pp. 96-97, 1943.

PHOMA FRUIT ROT

Phoma destructiva PLOWR.

ALTHOUGH this fungus also attacks the leaves and stems the greatest damage caused by it is through its attacks on the fruit. Generally speaking it is only serious on outdoor tomatoes. Lesions on the fruit usually appear on the stem-end, but they may develop on growth cracks, insect punctures, or wherever any injury to the fruit has occurred. The first symptom of disease is a water-soaked appearance of the affected spot. This enlarges rapidly, turns black on its surface and it may either become slightly depressed or not. Soon after discoloration black pycnidia develop on the surface of the portion attacked, and later the blackened area becomes thickly studded with these fructifications, Fig. 38, Plate XVII. The rot extends a considerable distance into the fruit which shrivels somewhat. During periods of high humidity the pycnidia ooze out their spores in long tendrils. The spores become splashed to other parts of the plant, and under suitable environmental conditions they germinate and cause infection.

On the leaves and stems the fungus gives rise to lesions irregular in outline and brown to black in colour. The infected areas on the foliage may be from one quarter to half an inch in diameter, and in cases of severe attack the spots may coalesce up and the leaves shrivel, turn yellow and drop. Foliage and stem infections often occur on the lower part of the plant and are frequently overlooked.

Control consists in removing and destroying all infected fruit, and so far as possible plants grown out-of-doors should be firmly staked and all possible measures taken to protect the fruit from injury.

II. Bacterial Diseases

BACTERIA are extremely minute, unicellular organisms, which the microscope reveals as consisting of three comparatively simple basic forms, namely :

(1) Spherical forms, called COCCI.

(2) Cylindrical or rod like forms, the BACILLUS type.

(3) Spiral forms, the SPIRILLI.

Some genera are furnished with flagella. The only method of reproduction amongst bacteria is by cell division, the typical mode of increase being the simple division of a mother cell into two daughter cells. The rapidity with which the fission can proceed depends on the environment. Under suitable conditions of food and temperature cell division can occur in from twenty to thirty minutes, and a single cell may produce a progeny of many hundreds of millions within twenty-four hours. This helps to explain the rapid multiplication of an organism in affected tissue, and also the serious effects which so often follow bacterial infection. Depending on the species and on the planes in which cell division takes place, after division the daughter cells may immediately separate or remain attached, forming chains or other aggregates. Some species of bacteria tend to produce spores. Where bacterial spores are produced they are long lived and very resistant to adverse conditions, some of them even surviving ordinary methods of sterilization. Bacterial spores serve mainly for the perpetuation of the species during unfavourable periods, and they do not function to any extent in the propagation and dissemination of the organism in the same way as do the spores of fungi. Furthermore, spore formation appears to be of unusual occurrence amongst bacteria causing plant diseases.

The vast majority of bacteria are saprophytes, but certain species are responsible for some of the most deadly diseases occurring in man and other animals. In plants, many soft rots of fruit and vegetables are due to bacteria ; some species cause spotting of the foliage, which often results in a shot hole effect ; some produce cankers ; others malformations and galls, and some wilt diseases. These wilt diseases are chiefly caused by *bacillus* forms and are nearly always fatal, the organism invading and choking the water and sap conducting vessels of the host.

BACTERIAL STRIPE

THE tomato disease formerly known as Bacterial Stripe, and which was usually ascribed to the organism *Bacillus lathyri*,

appears in the past to have been hopelessly mixed up and confused with streaking due to virus diseases. Indeed, at the present time, quite a number of workers question the occurrence of such a disease as Bacterial Stripe at all. This malady is much rarer than streaking caused by viruses. In Ireland bacterial infection has occasionally been found in plants affected with virus diseases, and in such cases it has been difficult to say what proportion of the streaking, if any, was caused by the bacteria and how much of it was the result of virus infection. At the same time, during investigation of tomato diseases here in Ireland, previous to 1947 there had been cases of plants coming to hand where only bacterial infection could be elucidated. The number of these specimens has admittedly been very small, and in every instance they consisted of plants with an extremely soft type of growth, indicative of excessive supplies of nitrogen.

Symptoms of disease on such plants were more or less streaking of the stems and petioles, discoloration of the vascular system and wilting. It was found that organisms isolated from these infected plants were only slightly pathogenic to other tomato plants, taking most easily to those having a soft luxuriant growth but difficult to establish on plants with a more hardy type of growth. This kind of bacterial infection did not spread to any extent under glasshouse conditions, and it was seldom that more than one or two plants in a house showed the disease. Also, control of this malady was easily effected by the removal of diseased plants.

This was the position in Ireland up to 1947, when an entirely new and more virulent bacterial disease appeared in several counties, and one which caused considerable loss to the growers.

BACTERIAL CANKER OF TOMATO

Corynebacterium michiganense (E.F.SM.) JENSEN

This serious bacterial disease of tomatoes was first observed in Michigan, U.S.A., and was described in 1909 by Dr. E. F. Smith. In the beginning Dr. Smith called it "The Grand

Rapids Disease" after the district where it was originally found, but afterwards he changed its common name to Bacterial Canker (3). The disease is now known to occur over most of the North American continent, and it has spread to parts of Australia, New Zealand and Europe. Its introduction into Great Britain has been comparatively recent, the first authentic outbreaks occurring in commercial glasshouses in the south of England in 1942. These have been reported on by Ware and Glasscock (4), who state that the disease again appeared the following year in outdoor plantations. Further outbreaks in England in later years have been recorded by Moore (2).

OCCURRENCE OF BACTERIAL CANKER IN IRELAND. Specimens of tomato plants affected with a bacterial disease, not hitherto observed in Ireland, were received by the writer on 12th June, 1947. These plants were forwarded by a Co. Dublin tomato grower who viewed them with apprehension. They were grown in a glasshouse and raised from imported seed. Subsequent investigations proved that the malady was Bacterial Canker due to the organism *Corynebacterium michiganense*. During the month of July 1947 further specimens similarly diseased came to hand from four other growers. One of these was in Co. Dublin and one each in counties Donegal, Cork and Limerick. In all five cases a considerable loss of plants occurred.

In 1948 the disease occurred on a more extensive scale, fifty-nine separate outbreaks being identified before the end of July, with the percentage of infected plants ranging from 0.2 to 20 in different glasshouses.

SYMPTOMS. Plants of all ages are liable to be attacked by Bacterial Canker. The grower's attention is generally drawn to the presence of the disease by browning and curling of some of the leaves. One or more leaves wilt. In some cases, only the leaflets on one side of a petiole or the foliage on one side of the plant may be affected. A close examination shows light brown to dark coloured dry lesions on the stems, petioles and veins of the leaflets. Streaking of the stem is often worst on its lower part. A lesion may be faint or well developed, and it may extend

FIG. 39. TOMATO PLANT ATTACKED BY BACTERIAL CANKER, *Corynebacterium michiganense*. FINAL STAGE OF THE DISEASE.

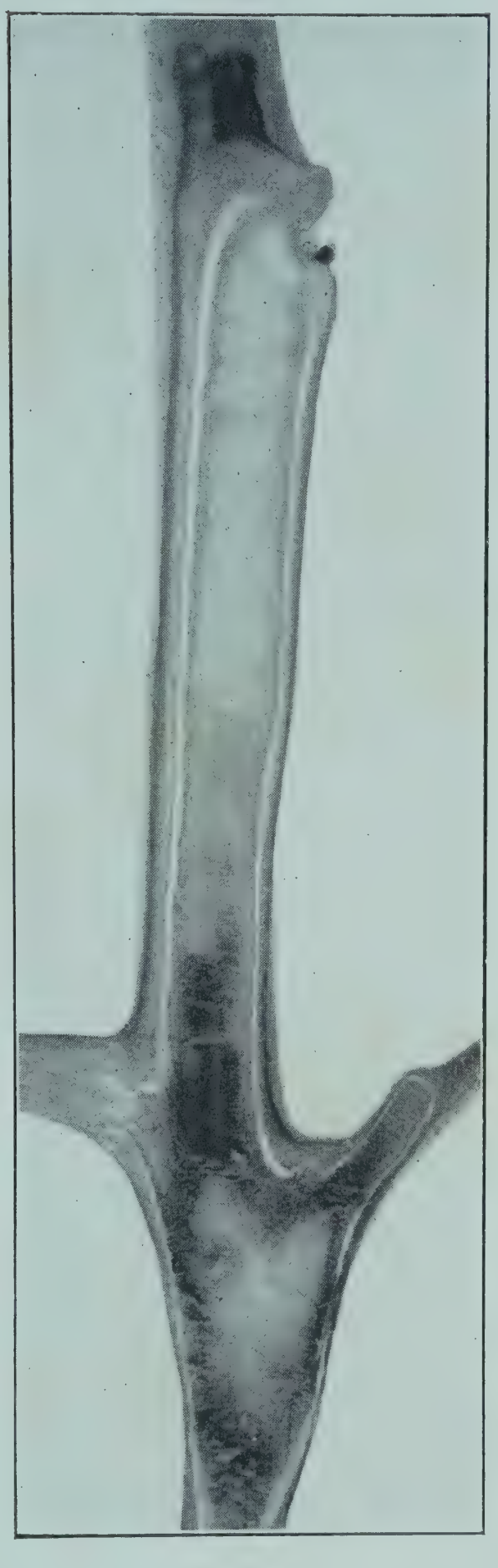

FIG. 40

FIG. 41

FIG. 40. LONGITUDINAL SECTION OF TOMATO STEM INFECTED WITH BACTERIAL CANKER SHOWING BROWNISH VASCULAR TISSUE AND MARKED DISCOLORATION AT THE NODES.

FIG. 41. SPLIT TOMATO STEM SHOWING LATER STAGE OF BACTERIAL CANKER ; THE PITH IS BEING DESTROYED AND CAVITIES ARE FORMING IN IT.

almost the entire length of an internode. Where streaks are long they have a tendency to be widest at their base and fade out into faint lines towards the upper end. Wilting of the entire foliage takes place as a rule rather slowly, but on very young plants and on those growing luxuriantly the disease develops more rapidly, and the stem lesions then become sunken and present a moist slimy appearance on their surface. When a diseased stem is split longitudinally the internal symptoms are discoloration of the vascular system and pith, accompanied by formation of cavities in the latter, Figs. 40 and 41, Plate XIX. The colour of the diseased tissues varies from light brown to dark brown, and it frequently extends much higher inside the plant than any external streaking of the stem. In addition to necrosis of the main stem the vascular system of the petioles is also affected, discoloration being worst at the nodes. This is best seen when leaves of a diseased plant are cut off close to the stem. The discoloured tissues will then be found as yellow or brown dots arranged in the form of an open ring or horse-shoe shape pattern. In the final stages of the disease that portion of the stem which was first invaded becomes completely hollow, the cortex collapses and the whole plant wilts, Fig. 39, Plate XVIII.

Stalks of the fruit trusses may also show lesions, but even when no streaks are visible on pedicels the fruit will often be found to be diseased. On cutting apparently sound fruit taken from affected plants, two dark coloured streaks at the calyx end indicate an infected vascular system through which the bacteria passed into the berry. This invasion of the fruit leads to seed infection. Advanced stages of the disease in the fruit result in a browning and break-down of the internal tissues.

A characteristic surface spotting of the fruit has also been described by Bryan in America (1) and by Ware and Glasscock in England (3). It apparently only occurs under certain environmental conditions. Typical spots are reported as having raised brown centres, each surrounded with a white halo and about one-tenth of an inch in diameter. As these spots develop their centres crack and they then appear rough on the surface.

Occasionally some spots are completely white without any raised centre. This skin spot of the fruit is caused by rain and moisture carrying the bacteria to the fruit from lesions elsewhere on the plant.

CONTROL. Bacterial Canker is a seed-borne disease, the organism *Corynebacterium michiganense* occurring both on the surface of the seed and internally in its tissues. Infected seed is the main method by which the disease is spread. Wherever disease producing micro-organisms occur inside the seed coat effective seed treatment is difficult to carry out, and Bacterial Canker of Tomatoes is no exception to the rule. Only disease free seed should be used, and seed should be obtained from areas where the disease does not occur. In no case should seed be saved from houses where the disease was present.

Besides attacking the aerial parts of the plant the bacteria also invade its root system. All diseased plants should be carefully removed and burnt as soon as ever they are noticed. This applies equally to those slightly infected as well as to badly diseased specimens. If the former are left they act as sources of infection to neighbouring plants, and in any case they often fail to ripen their fruit. The destruction of plants which show perhaps only one or two leaves wilting may seem a drastic procedure to the grower, but it is absolutely necessary if the disease is to be checked and eliminated from the glasshouse. When destroying affected plants all string or tyings should be included. Where stakes have been used they may be sterilized in a two per cent. solution of formaldehyde. Bacterial Canker is highly contagious and is spread easily from plant to plant by ordinary cultural practices, infection occurring through stomata and wounds. Wherever outbreaks of this disease occur, all plant material should be completely destroyed immediately the fruit has been picked. In addition to transmission by seed the disease may also be carried over in crop refuse in the soil, but the latter is not considered to be a serious factor in its perpetuation. At the same time, where the disease has appeared in glasshouses, if it is at all possible, some method of soil sterilization should be carried out as a precautionary measure.

FIG. 42

FIG. 43

FIG. 42. TOMATO LEAF INFECTED WITH COMMON TOMATO MOSAIC, *Nicotiana Virus I.*

FIG. 43. TOMATO SEEDLING NATURALLY INFECTED WITH SINGLE-VIRUS STREAK, *Lycopersicum Virus I,* SHOWING ROLLING OF LEAFLETS. (THIS IS NOT A CONSISTENT SYMPTOM.) (*Fig.* 43 *reproduced by permission from "Journal, Department of Agriculture, Eire," Vol. xxxviii.*)

FIG. 44. TOMATO PLANT INFECTED WITH SINGLE-VIRUS STREAK, *Lycopersicum Virus I.* NOTE: BASAL FOLIAGE HEALTHY UP TO GOOD TRUSS OF FRUIT: INTERMEDIATE FOLIAGE AND STEM SHOWING NECROTIC LESIONS AND ACCOMPANYING TRUSS OF FRUIT POORLY SET: TOP FOLIAGE MOTTLED ONLY.

REFERENCES :

1. Bryan, Mary K.—Studies on Bacterial Canker of Tomato. *Journal of Agricultural Research*, Vol. xli, pp. 825-851, 1930.

2. Moore, W. C.—Bacterial Canker of Tomato in England. *Journal of the Ministry of Agriculture, London*, Vol. liv, pp. 138-142, 1947.

3. Smith, Erwin F.—*Bacterial Diseases of Plants*, pp. 202-222, W. B. Saunders Co., Philadelphia and London, 1920.

4. Ware, W. M. and Glasscock, H. H.—Bacterial Canker of Tomato. *Journal of the Ministry of Agriculture, London*, Vol. l, pp. 499-503, 1944.

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III. Virus Diseases

VIRUS diseases of plants resemble to some extent those caused by fungi and bacteria in that many of them are extremely infectious, even much more so than diseases due to micro-organisms. They differ from most maladies caused by fungi and bacteria by the fact that once a plant becomes infected with a virus, infection spreads rapidly all through its tissues, the disease becoming systemic.* Viruses, however, are too small to be seen by usual microscopic methods, and one of their main characteristics is the very minute size of the causal agent present in diseased hosts. There are a few plant viruses which can be transmitted only by grafting or through the agency of insects, but in many of the group sap from diseased plants can be passed through filters made of collodion membrane, porcelain or kieselguhr and still retain its infective properties, although these filters are impermeable to all known living organisms.

Chemical substances of a complex protein nature have been obtained from plants affected with virus diseases, similar substances being absent from normal healthy plants of the same species. Investigations have shown that when these complex compounds were subjected to repeated purification and then inoculated into healthy plants typical disease symptoms occurred, along with the multiplication and production of identical chemical bodies. Hence, it is now believed that these peculiar proteins are the viruses themselves. Up to the present time there has been no evidence adduced that a virus can arise in any way except from a pre-existing virus. In this respect viruses resemble living organisms but whether they are animate or inanimate is a debatable point.

Although our knowledge of the viruses themselves is still very imperfect, in recent years a considerable amount of information has become available regarding virus diseases of plants, especially symptoms produced by particular viruses, methods of spread and means of prevention. The disease symptoms generally consist of one of the following features affecting the aerial parts of the host: chlorosis, alteration in size or shape of the foliage, necrosis, stunting, proliferation. Whatever the symptoms may be, the diseased condition is always accompanied by a reduction in the yield of the plant's economic product. It may be noted, however, that

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* Systemic infection means that once any part of a plant becomes infected with a disease, all new growth afterwards produced by that plant is infected from the time of its formation. In the majority of plants affected with a virus disease the seed alone escapes infection.

in bygone days certain virus diseased plants (especially ornamentals) had a considerable vogue and high commercial value, either on account of their mottled foliage as shown by the variegated Abutilon, or owing to the striking effect of the virus on the flowers as in "broken" tulips.*

In some cases virus infected plants may fail to show any symptoms and are then known as CARRIERS. Under natural conditions virus diseases are spread by means of insects, through contact of diseased and healthy plants, and by transfer of sap from infected to healthy plants during ordinary cultural operations. Some viruses have a very restricted host range, but others infect plants belonging to widely separated species.

Virus diseases of the tomato have been intensively investigated in several countries of the world, and those prevalent in Ireland have been adequately described by my colleague, Dr. Phyllis E. M. Clinch, to whose publication I am mainly indebted for the following particulars.

REFERENCE :

CLINCH, PHYLLIS E. M.—Virus Diseases of Tomato. *Éire Journal, Department of Agriculture*, Vol. XXXVIII, pp. 24-47, 1941.

COMMON TOMATO MOSAIC

Nicotiana Virus I

THE agent causing this disorder is also that responsible for the classical mosaic disease of tobacco, which was the first plant disease shown to be due to a virus. Although this is reported as the commonest virus affecting tomatoes in England such does not appear to be the case here in Ireland, as up to the time of writing it has never yet been isolated from diseased plants examined by the writer or his colleagues. Seeing that one of the sources of infection of this disease is stated to be tobacco used by workers in tomato houses, it is extremely unlikely that

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* Tulips which are raised from seed usually have flowers which are single coloured until virus infection occurs, after which the petals become mottled or piebald and they are then referred to as broken tulips, this condition being permanent.

The most famous broken tulip is *Semper Augustus*, a crimson and white ' flamed ' tulip. During the tulip craze in Holland in the early part of the seventeenth century, bulbs of *Semper Augustus* were frequently sold for 2000 florins, the peak price 13000 florins being paid for a single bulb in 1609.

the virus does not exist in this country. Moreover, as this malady is often confused with another virus disease of tomatoes much more prevalent in Ireland, it is thought best to describe the so-called Common Tomato Mosaic first, Fig. 42, Plate XX.

SYMPTOMS. In actively growing plants the disease becomes visible about nine days after infection occurs. Mottling appears in the young leaves on the top of the plant, certain areas being light green in colour and others dark green and blister-like. A similar mottle develops in other leaves and a slight stunting in the growth of the plant is noticeable. The leaves which are formed after infection are narrower, more pointed and have deeper indentations than normal. Under conditions of low light intensity, as in winter, stunting and leaf distortion are more conspicuous symptoms than mosaic mottling, the leaflets being sometimes reduced to mere thread-like structures. Mosaic symptoms develop mostly in young newly-infected plants and tend to fade as the foliage enlarges. The fruit seems normal but the reduction in yield is stated to be in the neighbourhood of ten per cent.

METHOD OF SPREAD. This is one of the most infectious virus diseases known. The virus can easily be conveyed by mechanical contact between diseased and healthy plants, and is most effectively spread in tomato houses through contamination of the hands, implements or clothes of the workers. Even a trace of the virus on hands or instruments may be the cause of infecting quite a number of plants. Several investigators have noticed that removal of lateral shoots of diseased plants followed by a similar operation on healthy plants has resulted in mass infection. Insect vectors do not appear to be involved in the spread of this virus.

SINGLE-VIRUS STREAK

Lycopersicum Virus I

This is easily the most common virus attacking tomatoes in Ireland, manifesting itself mainly in the form of mosaic. For

PLATE XXII

FIG. 45

FIG. 46

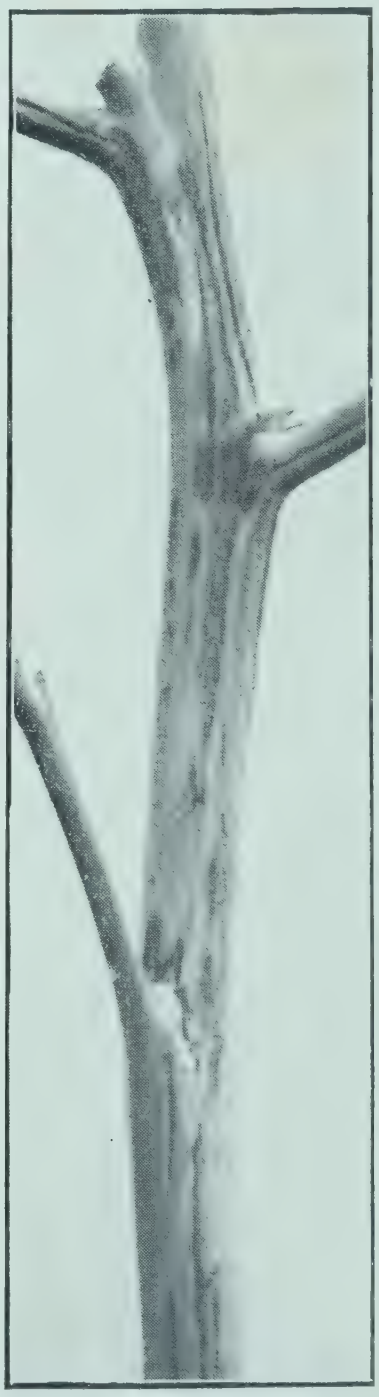

FIG. 47

FIGS. 45 AND 47. LEAFLETS AND STEM FROM BADLY AFFECTED PORTION OF PLANT IN FIG. 44, SHOWING NECROTIC LESIONS.

FIG. 46. LEAF FROM TOP OF PLANT IN FIG. 44, SHOWING MOSAIC MOTTLE ONLY.

FIG. 48. LEAF OF TOMATO PLANT INFECTED WITH TOMATO AUCUBA MOSAIC, *Nicotiana Virus IC*, SHOWING BRIGHT MOTTLE.

this reason, the disease is often mistaken for the Common Tomato Mosaic.

SYMPTOMS. Single Virus Streak symptoms are somewhat variable. The disease first appears in a small percentage of young seedlings in the propagating house. Streak does not develop at this stage, nor indeed, is mosaic always obvious. The infected seedlings have a spindly appearance, the leaflets are narrow, the lobes pointed instead of rounded, and the veins stand out prominently. Rolling of the young leaflets along the midribs is also a symptom, but not a common one, Fig. 43, Plate XX. Although obviously diseased seedlings are usually discarded, some infected plants are inevitably set out into permanent quarters and mottling only becomes noticeable after they are established, and from these the infection spreads throughout the crop. Careful watch is required if diseased plants are to be detected and eliminated from the propagating house.

As a general rule, in the tomato house the symptoms consist of a mottling identical with that caused by Common Tomato Mosaic.* Under certain circumstances, however, the Single-Virus Streak produces a striking necrotic effect ; longitudinal streaks develop on the stems and petioles and irregularly shaped dark brown lesions occur on the leaves, Figs. 45 and 47, Plate XXII. Streaking may be slight or severe. Frequently following infection, the development of streak is so virulent that the leaves in the immediate region of the affected stem, owing to necrosis of their petioles, wither and hang down or fall off. Such an appearance gives the grower the impression that the plants are dying. An examination of the tops shows that this is not so. As the plant adjusts itself to the virus the top grows away and the new foliage only shows a mottle which is systemic. Where streaking occurs it is always as a primary symptom of the disease. On the other hand, if plants show mosaic symptoms first as is commonly the case (usually less

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* Single-Virus Streak and Common Tomato Mosaic produce the same kind of mottle symptoms on tomato plants, but each virus can be easily identified by inoculating the sap from the diseased host into certain other differential plants.

than five per cent. developing streaks) then necrotic symptoms have never been seen developing afterwards. Furthermore, when streaking is followed by systemic mosaic of the new foliage the plants do not revert to streak. In commercial crops in glass-houses streak occurs mainly in spring, its appearance coinciding with the removal of the lower laterals, a cultural practice which facilitates the rapid spread of the virus. The usual picture presented by a diseased plant at this time is for the basal three to six leaves to be well developed, normal and healthy, slight to severe streaking of the stem at a height of from two to five feet with adjoining leaves wilted and dying, and the top of the plant growing away with mottled foliage, Fig. 44, Plate XXI, and Fig. 46, Plate XXII.

It is seen, therefore, that subsequent to infection with Single-Virus Streak the plant may either develop mosaic symptoms or streaking at first and then mosaic. What exactly determines which of these symptoms develops primarily following infection has not been elucidated. Manurial experiments with pot plants have shown that the appearance of the necrotic form of Single-Virus Streak cannot be attributed directly to lack or excess of any manurial ingredient ; neither does the temperature appear to influence its development. While the variety may have something to do with the severity of streak symptoms, it is not the only factor involved.

Where streaking occurs the trusses in that region of the stem may fail to set fruit, or if fruit do form the berries are often marked with irregularly shaped, yellow sunken lesions. It follows that the yield of marketable fruit is liable to be seriously reduced by the development of streak, apart from the effects of mosaic on the plant as a whole. In the case of plants showing only mosaic, the fruit appears normal.

TOMATO AUCUBA MOSAIC

Nicotiana Virus IC

This rather spectacular mosaic which occasionally occurs in tomatoes soon attracts the grower's attention.

SYMPTOMS. These are consistent and characteristic, taking the form of a brilliant mottling which appears first in the young foliage eight to ten days after infection has taken place. Well defined bright yellow and white patches are interspersed with areas of light and dark green tissue, producing a conspicuous mosaic pattern which persists throughout the life of the plant, Fig. 48, Plate XXIII. The leaflets are slightly reduced in size and diseased plants have a spindly appearance and are slightly stunted. Small white stripes may be present on the stems as a primary phase of infection with this virus but there is no necrosis. The fruit from diseased plants is frequently mottled, yellowish blotches or rings appearing, which although only skin deep, detract from its value.

METHOD OF SPREAD. *Nicotinia Virus IC* is spread in the same manner as *Nicotiana Virus I* and *Lycopersicum Virus I.*

ENATION MOSAIC

Nicotiana Virus IA

This mosaic is not by any means common in Ireland but specimens of it have occurred spasmodically in outdoor plantations.

SYMPTOMS. The outstanding characteristic feature of this disease is the extreme malformation of the foliage, Fig. 49, Plate XXIV. The most usual abnormality is the complete suppression of the laminae, so that the leaves consist simply of long thin threads which may be curled or twisted, giving rise to the so-called "shoestring" leaflet. Other degrees of distortion also occur. There may be large numbers of very small leaflets crowded together on the rachis the leaf ending in a corkscrew tendril, or the under surface of the leaves may produce outgrowths of small additional leaves (enations). Diseased plants are generally stunted.

Enation Mosaic is liable to be confused with distortion of tomato foliage which occurs during the winter months in plants

affected with Common Tomato Mosaic. In the latter disease, distortion of the foliage occurs only under conditions of low light intensity ; but in Enation Mosaic the malformation of the foliage is a pronounced summer characteristic, distortion in the winter being slight. The disease might also be mistaken for Fern Leaf see Fig. 73, Plate XXXVII. In Fern Leaf, which is a non-infectious trouble, the blade of the leaflet is not so completely suppressed as in Enation Mosaic, but is abnormally long and narrow.

DOUBLE-VIRUS STREAK

Solanum Virus I + *Nicotiana Virus I* or strains thereof or *Lycopersicum Virus I*

The most injurious virus streak occurring in tomatoes in this country is that caused by a combination of *Solanum Virus I* with any of the viruses already described.

Solanum Virus I (often referred to as Potato Virus X) is a common virus present in many varieties of potatoes. Several strains of this virus are known to occur, the most prevalent being that which is so often carried in potatoes in a masked or latent form. When this virus is inoculated into healthy tomato plants only a mild mottling of the foliage follows, no symptoms appearing on the stem or fruit ; but when it is added to any of the tomato viruses previously mentioned then Double-Virus Streak results, and the combined infection renders the plants practically worthless. Though less common than Single-Virus Streak, specimens of tomato plants infected with Double-Virus Streak occur spasmodically both in glasshouses and outdoor plantations in Ireland.

SYMPTOMS. Simultaneous infection with the potato virus and any one of the viruses already described invariably results in the production of streak symptoms somewhat similar to those associated with Single-Virus Streak, but much more severe. Following infection of the young plants there is an

FIG. 49. LEAF OF TOMATO PLANT INFECTED WITH ENATION MOSAIC, *Nicotiana Virus IA.* SHOWING EXTREME MALFORMATION. (*Reproduced by permission from "Journal, Department of Agriculture, Eire," Vol. xxxviii.*)

FIG. 50. TRUSS OF TOMATO FRUIT SHOWING NECROTIC LESIONS DUE TO DOUBLE-VIRUS STREAK.

obvious check in growth after seven to nine days; the top leaves become pallid and develop numerous brown or blackish lesions, and dark, longitudinal, slightly sunken streaks appear on the main stem, petioles and peduncles. If the strain of potato virus X is a virulent one, the necrosis rapidly involves the whole top of the plant which subsequently dies: with weak strains of the virus the growing point survives, but the necrotic leaves frequently dry out and wither in the early stages of the disease. The leaves formed during subsequent growth are severely mottled and puckered, considerably reduced in size and also show necrotic lesions. The plant as a whole is badly stunted and of spindly habit. Infection of older plants bearing three to four trusses of green fruit is followed by similar symptoms on the young growth, but the leaves fully formed at the time of infection remain completely normal although streaks develop down along the stem almost to its base. Streaked plants set few fruit and any tomatoes which are formed are often rough and misshapen. Fruit spotting is also common and severe, irregular brown spots ranging in size from one-eighth to three-eighths of an inch in diameter occur scattered all over the fruit, Fig. 50, Plate XXV. These lesions at first are slightly raised above the surrounding surface but become sunken later.

Consequently, the main difference in symptoms between Single-Virus Streak and Double-Virus Streak is in the reaction of the plant following the appearance of streak. In Single-Virus Streak while necrosis of from twelve to eighteen inches of the stem along with adjacent foliage may be severe following initial infection, the top of the plant afterwards grows away mottled but without any streaking, and fruit which is subsequently formed is normal. In Double-Virus Streak lesions continue to appear on any new growth and develop also on the stem almost to its base, and fruit is badly marked: the only part of the plant remaining free from streaks being foliage which was well formed before infection occurred.

METHOD OF SPREAD. Both types of virus may be spread in the same way, that is, by contaminated hands or instruments or as a result of contact between healthy and

diseased plants. Very few tomato houses are free from Single-Virus Streak, occurring mainly in the form of mosaic. The potato virus can be introduced into tomato houses by workmen handling tomato plants after having previously worked with potatoes, or volunteer potato plants amongst the tomato plants can infect the latter by direct contact.

Two examples may be given of the way the potato virus can be unconsciously introduced into tomato houses. One case in which the writer was consulted was that of an outbreak of Double-Virus Streak in a new glasshouse cropped with tomatoes for the first time. Thirty per cent. of the plants at least showed severe necrosis of the foliage, stems and fruit and this happened before the end of May. The house was erected on lea ground and pieces of potato tubers had been used for trapping wire-worms in the soil. A number of these pieces had grown and the plants occurred scattered throughout the house. It was with the greatest difficulty that the grower was persuaded that these potato plants were the chief source of the disease. The outbreak in the second instance was even worse and developed earlier in the season. It arose from potatoes in sprouting boxes placed between the rows of tomatoes in order to hasten sprouting and at the same time keep the sprouts sturdy.

SPOTTED WILT

Lycopersicum Virus 3

The disease known as Spotted Wilt was first recognized and described in Australia in 1919 : its occurrence in England was noted in 1932, and it was identified on tomato plants in Ireland the following year. As many different kinds of plants act as host for this virus, and some of them carry it without showing any very obvious symptoms, the disease was probably present in these islands for a long time previous to its recognition. The disease is not by any means rare in Ireland, but outbreaks of it on tomatoes do not occur with anything like the same frequency as outbreaks of Single Virus Streak. This is fortunate,

because Spotted Wilt is undoubtedly the most serious virus disease of tomatoes at present known.

SYMPTOMS OF SPOTTED WILT ON TOMATOES.

The symptoms are rather variable, depending to some extent on the variety and also on the conditions under which the plants are kept. The disease may show up in from ten to eighteen days after infection occurs. In actively growing plants the young leaves become turgid, bend back on their petioles and the veins stand out prominently. The plant ceases to elongate normally, the top foliage curving downwards and clustering around the stem, and growth for the time being is arrested, see Frontispiece. This is followed by a sudden bronzing of the upper foliage. This discoloration has no very definite pattern, and it may appear as irregular spots, circles or blotches close to the veins. A leaflet may show a few bronze spots or its entire surface may be affected, or the whole leaf may be bronzed, as illustrated. The bronzing of well expanded leaflets usually develops from the base, but in younger leaflets it develops chiefly from the apex backwards. The bronze colour varies from a greenish brown to a dark brown glaze, and in dull weather it may persist for some time : under hot, sunny conditions the turgidity of the top disappears, the discoloured areas wilt, dry out, and shrivel up within a few days. Growth of the plant may be resumed later but is very slow ; the new leaves are distorted, the edges of the leaflets curl upwards and the entire plant is dwarfed. In this condition it may survive for months but is useless.

From the time the first symptoms of infection appear the development of the disease is rapid, and at the end of a week the difference between the top nine to twelve inches and the remainder of the plant is striking. The foliage on the former being dry, crisp and brittle ; whereas the older foliage shows little change, see Frontispiece.

The foregoing are the usual typical symptoms of the disease, but sometimes very little bronzing of the young foliage develops, the leaflets turning a pale yellowish-green and presenting a varnished or glazed appearance.

The bronze sheen of the younger leaflets (or pale yellowish-green varnished appearance), the accompanying downward curvature of the upper foliage, and the rapidity with which severe symptoms develop from the time infection is first seen, are all diagnostic features of Spotted Wilt.

Young plants are more susceptible to infection than old plants, and when young plants become infected symptoms develop rapidly.

The effect on the fruit depends upon the stage of development of the trusses at the time of infection ; if already well-formed the fruit may escape appreciable injury ; if small it is poor in quality and frequently displays conspicuous markings in the form of large yellow or brown concentric rings or blotches.

SOURCES OF THE DISEASE. One of the most dangerous features of the Spotted Wilt virus is its extremely wide host range, attacking as it does plants from nineteen different families. Many of these are commonly raised in glass-houses, often in company with tomatoes. The Arum Lily, Chrysanthemum and the Dahlia often serve as sources of this disease, but numerous other glasshouse plants are infected, as well as certain common weeds like bindweed, chickweed, great plantain, deadly nightshade and henbane. The symptoms vary greatly in the different hosts, and on many of them the effect of the virus is not nearly so severe as it is on the tomato, and diseased plants cannot always be recognized by visual observation. Symptoms on the Arum Lily are yellow streaks, blotches and rings on the leaves and white sunken streaks on the leaf and flower stalks : pale rings on the green flower buds, flowers deformed and plants stunted. On the other hand, symptoms on Chrysanthemums are sufficiently vague to escape detection, and the disease may be introduced unknowingly into new localities or glasshouses by cuttings of this host.

Holmes has shown that more than one strain of the Spotted Wilt virus exists, and that resistant tomato varieties which are raised and successful in certain places may succumb to the disease when grown elsewhere and brought into contact with other strains of the virus.

FIG. 51

FIG. 53

FIG. 52

FIG. 51. SUN SCORCH ON TOMATO LEAF.

FIG. 52. TYPICAL SUN SCALD ON TOMATO LEAFLET.

FIG. 53. SUN SCALD ON TOMATO.

PLATE XXVII

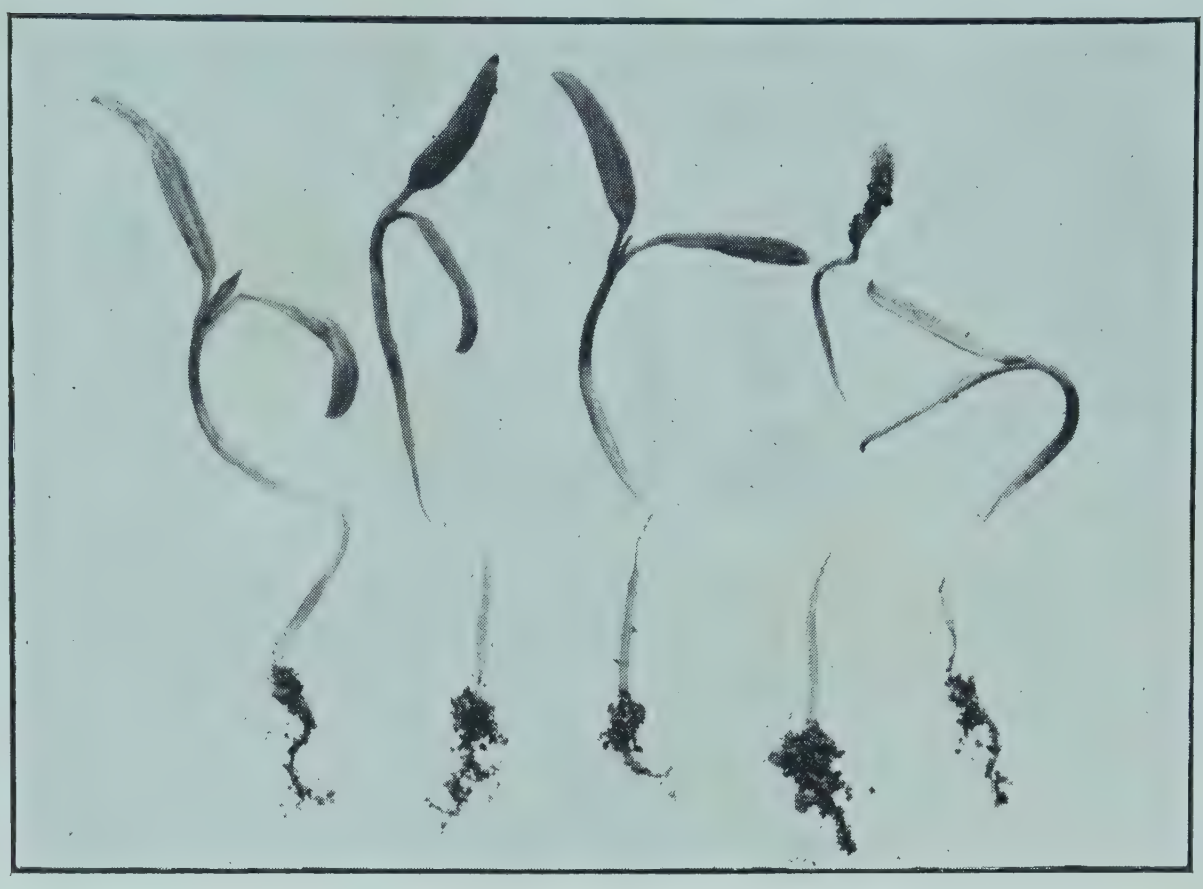

FIG. 54

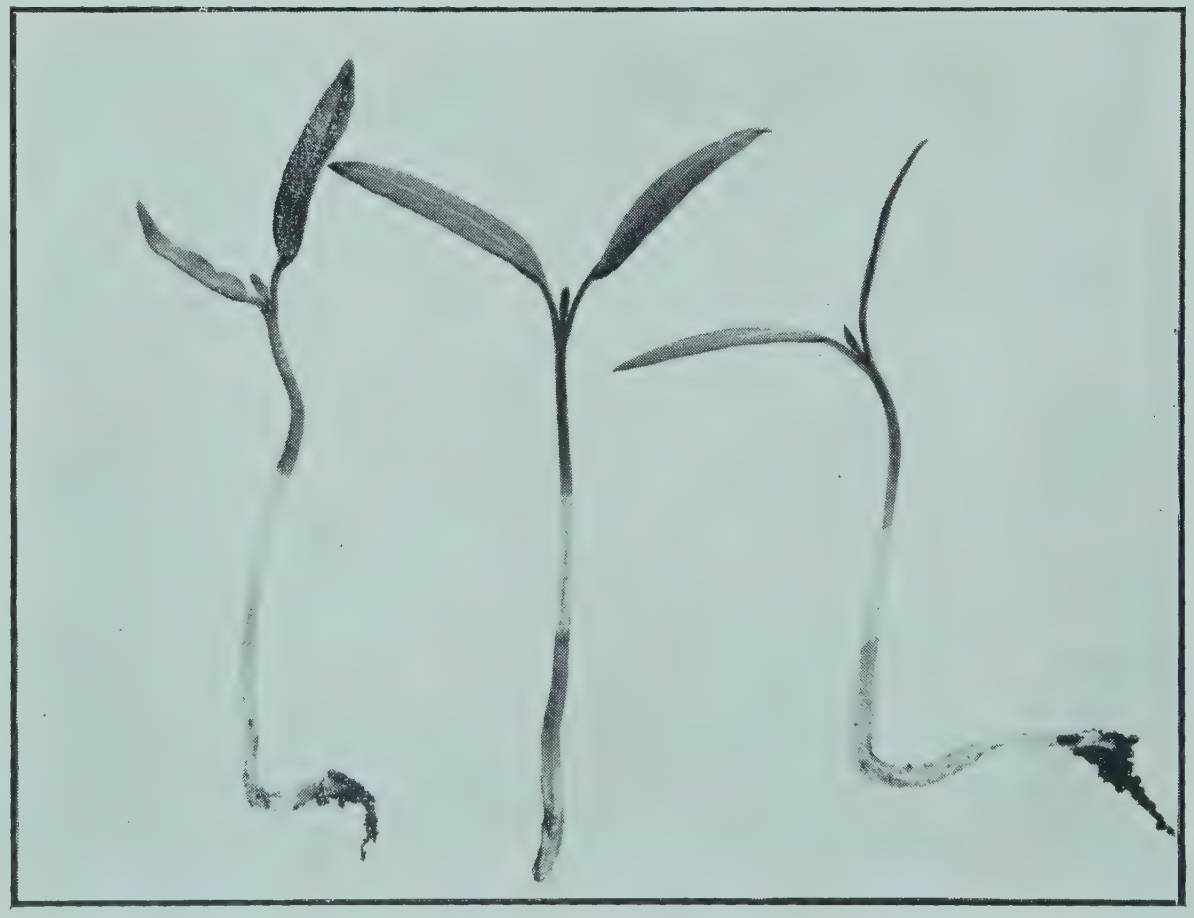

FIG. 55

FIG. 54. SEVERE SUN SCALD ON TOMATO SEEDLINGS.

FIG. 55. SEEDLINGS SHOWING LESIONS ON THEIR STEMS DUE TO SUN SCALD. (*Figs.* 54 *and* 55 *reproduced by permission from "Journal, Department of Agriculture, Eire," Vol. xxxix.*)

METHOD OF SPREAD. The chief and most effective method of transmission is by means of thrips (*Thrips tabaci L.*) These minute insects are omnivorous feeders and are exceedingly common in glasshouses as well as out-of-doors. In this respect the Arum Lily is a particular danger as it is a favourite breeding ground for thrips. The virus is also transmissible through the sap, and may be passed from infected to healthy plants on pruning knives or on the hands of workers. Spread in this manner, however, is comparatively infrequent, and infection does not readily occur unless the plants are young and growing actively and the source recently infected.

REFERENCE:

HOLMES, F. O.—Resistance to Spotted Wilt of Tomatoes. *Phytopathology*, Vol. XXXVIII, pp. 467-473, 1948.

CONTROL OF VIRUS DISEASES

THERE is no cure for plants infected with any of the virus diseases described. In this group once a plant is infected the disease becomes systemic, as already mentioned, and the plant then serves as a source of danger to healthy plants. Therefore, preventive measures are the only means that can be used for the control of virus diseases, and the following recommendations apply to tomato virus diseases in general.

Seed should only be saved from virus-free plants. The available evidence at present indicates that although the vast majority of seedlings grown from seed of infected plants may be healthy, a small percentage is liable to be diseased. In the case of Single-Virus Streak this malady has been seen repeatedly to occur in the seedlings at a very early stage. As the presence of one or two infected plants may easily lead to contamination of an entire crop, the advisability of using seed from virus-free plants cannot be over emphasized.

Tomatoes should be isolated as far as possible from other plants during their entire growing period. Ornamental plants

are often the source of the Spotted Wilt Virus and potatoes that of the main constituent of Double Virus Streak. Where tomatoes are being grown outside, the vicinity of potatoes and onions in particular should be avoided : onions (like Dahlias) frequently being infested with thrips.

Following germination, a close watch should be kept on tomato seedlings and any showing mosaic or other abnormality discarded. Apparently healthy seedlings actually touching a diseased one should be set aside until the incubation period of eight to ten days has elapsed, in case infection occurred.

Only plants which appear healthy should be set out in permanent quarters. As soon as the plants are established and making active growth and before the operations of disbudding and tying are begun, they should be examined carefully and any plant showing virus symptoms dug up and burnt. (Once disbudding has started it is extremely difficult to prevent the spread of disease by roguing, except in the case of Spotted Wilt.)

In the case of Spotted Wilt diseased plants should be removed and destroyed immediately they are seen.

Workmen should avoid smoking and chewing tobacco when handling tomato plants, especially in the young stages. Those who smoke can remove possible traces of infection from their hands by washing them well with soap and water before touching healthy plants.

The insect population of glasshouses should be kept as low as possible by regular fumigation.

Assuming that a crop has been infected beyond control, maintenance of a well balanced and sturdy type of growth will minimise the disease symptoms.

All plant remains at the end of the season should be collected and burnt, and sterilization of the soil by formaldehyde or steam is desirable.

IV. Non-Parasitic Diseases

The diseases listed under this heading may be divided up into three separate groups, namely :

(1) Damage caused by unfavourable environmental conditions and physiological disturbances set up in the plant by the same factors.

(2) Malnutrition.

(3) Chemical Injury.

These maladies are not infectious. As a rule, they are more difficult to diagnose than where parasitic organisms are involved. The damage done may show up soon after a particular agent operated, or its appearance may be delayed and only develop after some considerable lapse of time, or again, results may be cumulative and symptoms appear gradually and become chronic.

Malnutrition is caused by a deficiency of some essential plant nutrient. The substance may be lacking in the soil, or it may be present but tied up in chemical compounds which are useless to the plant. Deficiency symptoms may appear during the early stages of the plant's development, but usually there are sufficient nutrients available to support growth in the young stage and the symptoms only appear when maximum demands are being made on the plants, that is when they are carrying their full crop. Signs of something amiss may then develop rather suddenly. Many of the factors concerned in malnutrition are still imperfectly understood, and only a few cases of those relating to the major elements are here included, as they have been the most thoroughly investigated. It is obvious that in all deficiency diseases the water supply is of the utmost importance, because on this depends the solution of nutrients and hence their availability to the roots.

BLUE OR PURPLE DISCOLORATION OF SEEDLINGS AND YOUNG PLANTS

Accompanying a purplish discoloration of the foliage of young plants there is generally a hard and unthrifty appearance with poor growth. Various factors may be responsible for this condition but the most usual cause is cold. Where tomato

seedlings are raised at too low a temperature they invariably make slow progress and the leaves turn bluish. The temperature of the propagating house should not be allowed to drop below 60°F. at night and it should be in the neighbourhood of 65°F. during the daytime if satisfactory growth is to be maintained. Beyond the mere seedling stage this purplish discoloration may develop in the plants at any time until they are ready for staking. Frequently it appears on plants after they are set out in their permanent quarters. Here again its development is due to too low a temperature, either of the house in general or of the soil. It is important to remember that in the early months of the year it is essential to have the soil warmed up sufficiently before planting out. The temperature of the soil is as important as that of the air : not infrequently plants from a warm house are set out into a cold wet soil, with the result that root action practically ceases, and the check is so severe that some considerable time elapses before they recover. Valuable time is lost in such cases, and the retarded plants are more susceptible to attack by soil fungi than where growth is continuous.

A second factor causing this trouble is lack of phosphates, the discoloration commonly developing in seedlings raised in soil sterilized by heat. Where seedlings are developing a bluish tinge and the factor of too low a temperature can be ruled out, a sprinkling of phosphates to the soil will generally result in a recovery to the normal green colour. It has previously been stated that a rich soil is not necessary for raising seedlings, but where soil for the seed-boxes has been sterilized, it is recommended to give a light dressing of superphosphate to the compost used, owing to the tendency for such soil to be deficient in available phosphates.

A more advanced stage of discoloration and severe stunting results from attempting to raise plants in soil which has been rendered practically sterile by over-heating. Where this has occurred, a fresh sowing of seed in good soil will give quicker and better results than any attempts to correct the sterility of soil which has been over-heated.

FIG. 56. DRY SET ON TOMATO TRUSS.

PLATE XXIX

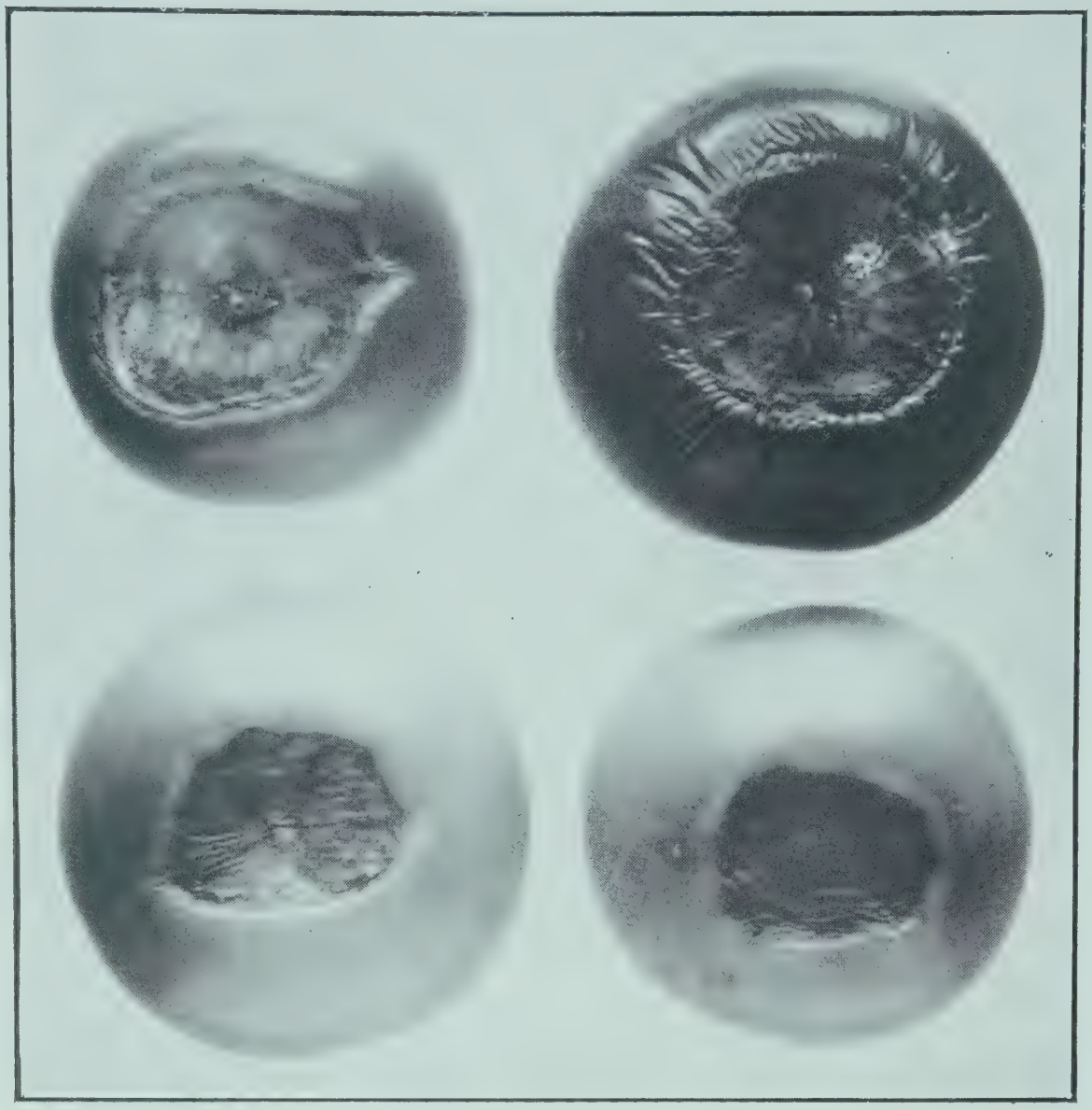

FIG. 57

FIGS. 58

FIG. 59

FIG. 57. BLOSSOM END ROT ON RIPE FRUIT AT TOP AND ON GREEN FRUIT BELOW.
FIGS. 58 AND 59. CRACKING OF TOMATO FRUIT.

SUN SCORCH AND SUN SCALD

SUN SCORCH. When soft young foliage of tomato plants is brought too near the glass a marginal leaf scorch is liable to develop. This is characterized by a disappearance of chlorophyll, browning, shrivelling and drying up of the injured tissues, Fig. 51, Plate XXVI. Scorch of this type may occur either in the propagating house early in the season or later when the tops of older plants approach the roof, and it is more liable to take place during intermittent spells of bright sunshine in dull cloudy weather than when the days are continuously bright. The limited area of the young tender foliage affected, the abrupt transition from injured to healthy tissue, and its position on the plant, serve at once to diagnose this trouble from scorch due to unbalanced nutrients.

SUN SCALD. This is the name given to dead, yellowish white patches which appear between the veins of the leaflets, Fig. 52, Plate XXVI. It frequently develops as a result of the rays from a bright sun striking young tender plants, particularly when moisture is present on the foliage. The green colour fades on the affected area, which first becomes blister-like, but which soon shrinks and forms a large flattened, yellowish-white spot with a thin, dry paper-like texture as illustrated. Similar dead areas may appear on any foliage during very bright sunlight following a period of dull cloudy weather. Sun Scald may also appear on the tomatoes, green immature fruit being most subject to it when they are exposed to a bright sun, either on or off the plant. The spot on the fruit may remain yellow as the fruit ripens, but more frequently a blister-like area develops which afterwards flattens and possesses a dry paper-like surface, Fig. 53, Plate XXVI.

Occasionally Sun Scald may be caused by imperfections in the glass used in the construction of the greenhouse, or through a focussing of the sun's rays by an overlap of certain panes of glass. In such cases it will be found that the injury always appears on plants in a restricted area of the house, and by careful observation the location of the pane or panes involved can

generally be ascertained, when they may either be removed and replaced or shaded by a light application of whitewash or summer cloud.

A more unusual type of heat injury is Sun Scald on tomato seedlings, as illustrated in Figs. 54 and 55, Plate XXVII. In those slightly affected, white spots or lesions occur on the side of the stems facing the sun, the cells of the cortex being injured to varying degrees in depth. In the more severe cases the stems are constricted, the entire cortex being killed. This damage resembles Damping-off to some extent, the seedlings collapsing at soil level in groups or patches ; but there is no water-soaked discoloration of affected parts, and when injured seedlings are kept in a moist atmosphere healthy roots develop freely from above the constricted portion. The combined factors which tend to produce this damage are :

(*a*) The mixing of cement flue dust, soot or similar substances with the compost used for raising the seedlings.

(*b*) A temperature of from 82–86° F. in the propagating house.

(*c*) Full exposure of the seedlings for a couple of hours to direct sunlight, even in the month of March.

Black soils readily absorb the sun's rays, and the addition of cement flue dust, soot or similar substances, not only darkens the compost but tend to render it fine in texture, so that the surface is liable to form a crust on drying out after watering. When the surface cakes the crust acts as a conductor of heat to the plants, whereas when the top layer is not compacted but loose, little air pockets about the young stems act as insulators and protect them from injury. The most sensitive time for seedlings is just after they emerge from the soil, and they should be shaded to some extent if the weather is at all bright and sunny.

FLOWER DROP AND DRY SET

For pollination of tomato flowers to be effective the environmental conditions must be favourable. The flowers are very sensitive to lack of moisture, and any shortage or interruption

to the plant's water supply is invariably followed by flower dropping. Healthy blooms are indicated by their bright yellow colour and the turgidity of their dark green stems. Where water is lacking, although the flowers open their colour is dull, their stalks yellowish and limp, and the flowers fall off at the joint. In addition to drought at the root other factors which cause flower drop, are :

(*a*) A very dry atmosphere.

(*b*) A low temperature (especially at night).

(*c*) Excessive applications of nitrogenous fertilizers.

Overhead damping corrects the dryness of the atmosphere and assists pollination and fertilization. Syringing the foliage should commence with the opening of the first flower and it should be continued until practically all the crop has set, unless *Cladosporium fulvum* threatens to become virulent. Overhead damping is best carried out in the morning, and during bright sunny weather it may be necessary to repeat it two or three times during the day. Sufficient time should be allowed between the last application and sunset so that the foliage dries before nightfall.

DRY SET. In this condition the flowers do not drop prematurely but the ovary remains small and undeveloped. Few or many flowers on the truss may be affected, Fig. 56, Plate XXVIII. The cause of the trouble here is imperfect pollination which is nearly always due to too dry an atmosphere.

BLOSSOM END ROT

This troublesome disease appears to be known wherever tomatoes are cultivated, occurring both on outdoor plants and on those in glasshouses. Practically all tomato growers meet with Blossom End Rot sooner or later, and once the disease appears, serious losses may follow unless close attention is paid to cultural operations and especially to watering. The uninjured part of the fruit is quite suitable for home consumption,

but fruits even slightly affected with Blossom End Rot are completely spoiled for market purposes, and more than half the crop may be disfigured when conditions favour its development.

SYMPTOMS. As indicated by its name the damage is always associated with the blossom end of the fruit, no other disease in this country resembling it. All sizes of fruit are liable to develop the rot, but it is more prevalent on those that are about an inch or more in diameter. The amount of fruit surface blackened and destroyed is variable, ranging in size from a small spot just visible to an area the size of a penny, or sometimes involving half the fruit. The rot—which is essentially a dry rot—starts as a small spot resembling a bruise on the blossom end. The affected tissues cease to grow, the skin over them flattens, darkens, and finally becomes black, Fig. 57, Plate XXIX. The damaged fruits are usually carried until they reach maturity. The diseased area spreads in an ever widening circle with the growth of the fruit until the latter begins to ripen, when further expansion of the affected part ceases. The lesion eventually becomes sunken on developing fruit, but where fruit is almost fully grown before the disease develops the lesion is seldom depressed but only flattened. The line of demarcation between the dead and healthy tissues is sharply defined, and in affected fruits the development of red not infrequently begins around the edge of the lesion and proceeds towards the stem-end. The dead tissues are firm and somewhat leathery in texture, and the sunken lesions, although they may be present for several weeks, are unaccompanied by any soft rot of the tomato unless secondary organisms gain entrance. Typical Blossom End Rot in green and ripe fruit is shown in Fig. 57, Plate XXIX.

CAUSE OF THE DISEASE. According to Brooks (1), Galloway first drew attention to this trouble in America in 1888. From that time until now, owing to the serious losses caused by it throughout the world, Blossom End Rot has been the subject of numerous investigations and many papers published on it. For almost a quarter of a century after it was

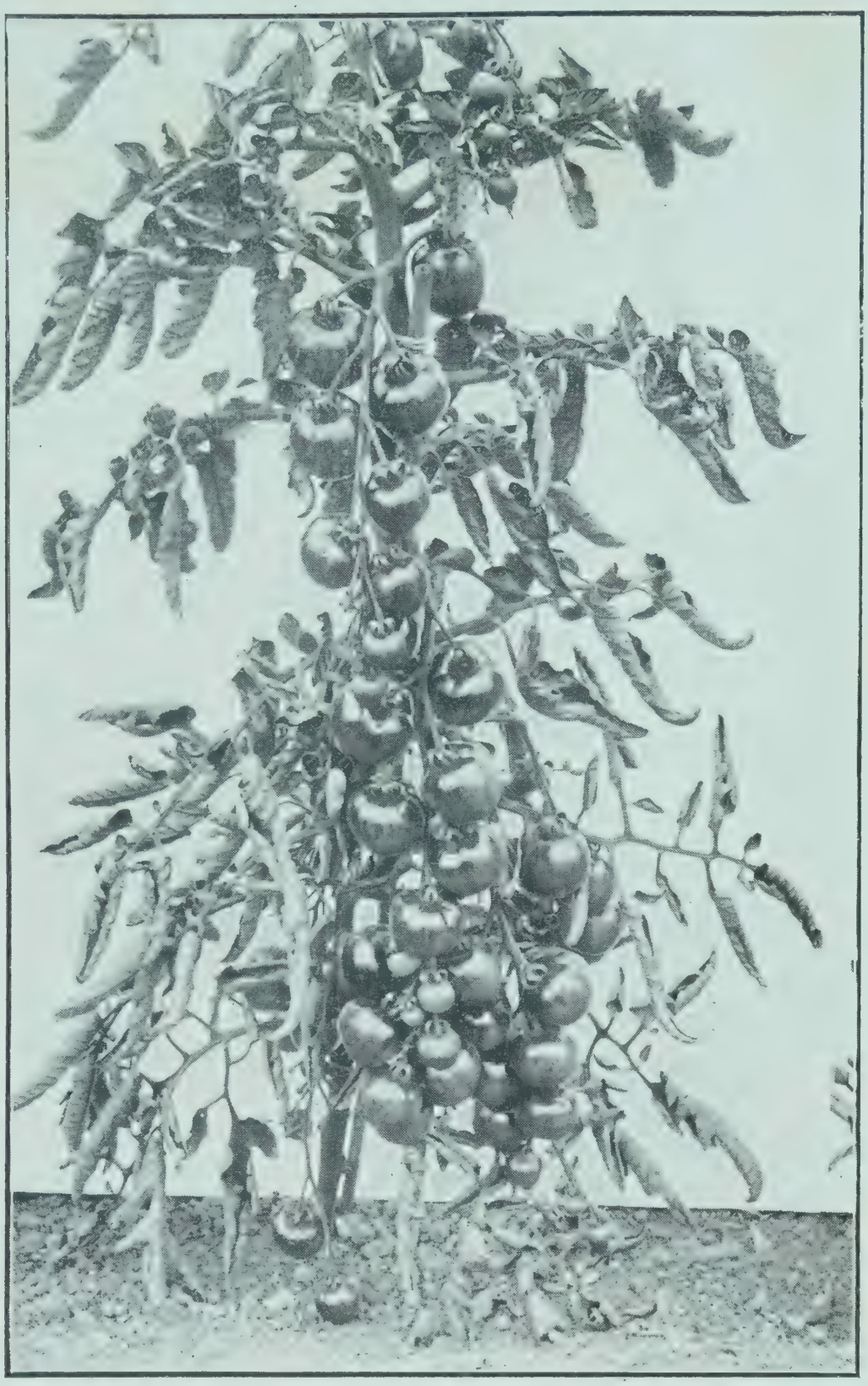

FIG. 60. ROLLING OF FOLIAGE ON OUTDOOR TOMATO PLANT.

FIG. 61

FIG. 62

FIG. 61. INTUMESCENCES ON LOWER SURFACE OF TOMATO LEAFLET.

FIG. 62. OEDEMA OR DROPSY ON TOMATO STEM.

first reported the disease was believed to be due to parasitic action, and it was imputed to many different micro-organisms by various workers. At the same time some of the earliest investigators maintained that it was non-infectious and attributed the main cause of the trouble to be lack of water. Since 1914 it has generally been conceded that Blossom End Rot is wholly physiological in nature ; the plant withdrawing water for its needs from the blossom end of the fruit during periods of scarcity. Time and again it has been produced experimentally through manipulation of the water supply to the plants and also by the concentration of nutrient salts in the soil. But even when Blossom End Rot develops where the concentration of nutrient salts is high and plenty of water present in the soil, the real cause may still be drought, the plants not taking in the concentrated solutions and suffering from lack of water in consequence. The conditions under which the disease is liable to occur are fairly well known, and they may be stated as follows :

(*a*) Tomatoes show a varietal difference in their susceptibility to Blossom End Rot.

(*b*) The disease is generally worse on sandy soils than on clay.

(*c*) Soft luxuriantly growing plants are more liable to develop the disease than those making a slow and more uniform growth : plants grown continuously in low soil moisture appear to be resistant to the rot, due apparently to their hardened condition.

(*d*) Rapid fluctuations in soil water favour the disease, particularly if a sudden check to the water supply occurs after excessive watering. If the water supply is reduced gradually and uniformly no rot may develop.

(*e*) Increasing amounts of ammonium compounds, such as stable manure, dried blood, and sulphate of ammonia, favour the development of the disease when other conditions are conducive.

(*f*) In controlled experiments it has been found that most

Blossom End Rot invariably appeared where the concentration of nutrient salts was high, whereas in low concentrations the amount of disease was nil or negligible.

(*g*) The disease has been associated with calcium nutrition by Lyon, Beeson and Barrentine (2), and it is generally worst where calcium is low and potassium and magnesium high.

CONTROL. It is obvious from the foregoing statements that the prevention of the disease relies mainly on cultural practices. Regularity in the water supply to the plants is the most important factor in control of Blossom End Rot, and any treatment which ensures an even uniform growth tends towards the same end. Excess watering or fluctuating water supplies which result in intermittent growth should be avoided, as well as large quantities of fresh stable manure or overdoses of fertilizers. Applications of lime to the soil are beneficial.

REFERENCES :

1. Brooks, C.—Blossom-End Rot of Tomatoes. *Phytopathology*, Vol. iv, pp. 345-373, 1914.
2. Lyon, C. B., Beeson, K. C. and Barrentine, M.—Macro-element nutrition of the Tomato plant as correlated with Fruitfulness and occurrence of Blossom End Rot. *Botanical Gazette*, ciii, 4, pp. 651-667, 1942.

CRACKED FRUITS

Cracking of tomato fruits is mainly physiological in nature. It is usually a form of second growth similar to what occurs in potato tubers and other root crops, and it is generally due to the same factors, namely, alternating periods of drought and abundant water supplies. If tomato plants are allowed to get dry at their roots during the development of the fruit, swelling of the fruit ceases more or less and their skin tends to mature and harden. On the resumption of growth following copious watering the mature skin can neither expand properly nor

withstand the increased pressure within, hence the fruit cracks, Figs. 58 and 59, Plate XXIX.*

Growth cracks of this nature appear chiefly on the basal parts of the fruit, either radiating from the stem-end or the rupture developing around the fruit. The cracks vary in width and in depth to which penetration of the flesh occurs, but the exposed tissues heal over to some extent. Irregularity in the water supply is the main cause of this trouble, but it may also follow the application of nitrogenous fertilizers or a sudden increase of temperature producing rapid growth. Susceptibility to cracking is a characteristic of certain varieties. Fruit blemished by cracking is reduced in market value, as besides detracting from its appearance the cracks are liable to burst open during transit, and in addition they provide suitable points of entrance for various organisms causing fruit rot.

CONTROL. This consists in attention to watering, ventilation, manuring, and any factor which ensures a uniform growth of the plants. Cultivation of very thin skinned varieties subject to cracking should be avoided.

GREEN BACK

This is the name given to fruit on which the stem-end area remains green and hard while the remainder is ripening. Although such hard areas may eventually become yellow or orange they never colour red and are insipid in flavour. Green Back is very often prevalent on tomatoes grown outside, but it may also cause considerable loss under glasshouse conditions. For a long time this trouble was considered as a form of malnutrition, the evidence adduced being that applications of

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* An entirely different cracking from the above is rather common on tomatoes grown outside, and it occasionally occurs on indoor plants. This cracking takes the form of a mesh or net-work arrangement of fine hair-like cracks, affecting either one side of the fruit (that most exposed) or covering its whole surface. Such fruit appear as if they were covered with a scurf and they feel rough. Damage of this kind is caused by frost and inclement weather.

fertilizers to the soil were known to reduce the percentage of affected fruit. Potash in particular seems to be important in this respect, and dressings of it tend to render tomatoes resistant to the disorder. At the same time, tomatoes ripen in the shade better than in the sun, and excessive sunlight injures the tissues on the base of the fruit and prevents the formation of red pigment.

Control of Green Back is chiefly achieved by providing protection to the ripening fruit. Sufficient foliage should be left on the plants to protect the fruit, or if necessary, a slight shading may be applied to the glass during the height of the summer.

BLOTCHY RIPENING

Blotchy Ripening is one of the names given to fruit which, in the absence of any infectious disease in the plant, ripens unevenly. This trouble is somewhat similar to Green Back, but the unripe areas are not on the basal end of the fruit but occur elsewhere, Fig. 64, Plate XXXII. Usually there is no sharp line of demarcation between the affected spot and the normal tissue. In severe cases the discoloured areas are glassy in appearance and remain firm even when the remainder of the fruit is over-ripe. It is generally believed that Blotchy Ripening results to a large extent from malnutrition. In New Zealand this condition is known as Cloudy Fruit. Applications of potash and nitrogen to the soil reduce the percentage of affected fruits. However, very often no manuring will eliminate it completely, and other factors not understood at present enter into the cause of this disease.

ROLLING OF TOMATO FOLIAGE

In this country rolling of tomato foliage is a common feature on plants grown out-of-doors, but it may also develop in glasshouses where its appearance occasionally gives rise to apprehension amongst amateurs. Rolling of tomato leaves in glasshouses generally occurs on plants opposite ventilators and at

PLATE XXXII

FIG. 63

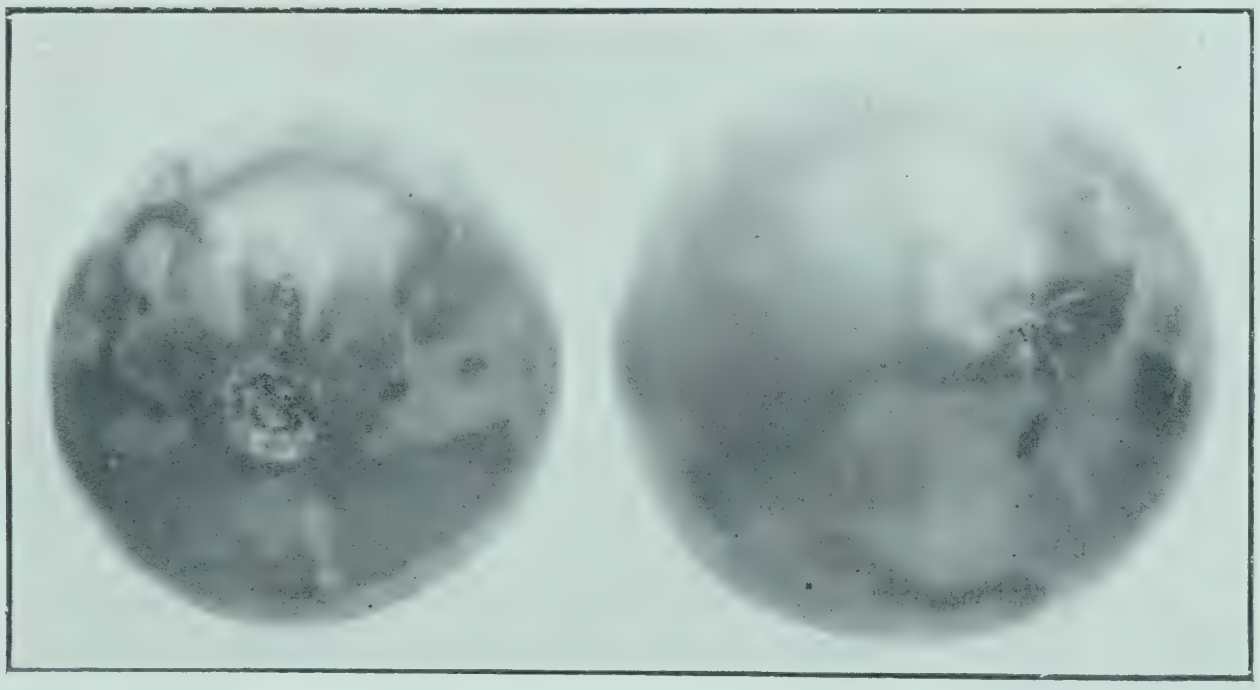

FIG. 64

FIG. 63. SYMPTOMS OF POTASH DEFICIENCY IN TOMATO LEAVES.
FIG. 64. BLOTCHY RIPENING OR CLOUDY FRUIT.

FIG. 65

FIG. 65. IRON DEFICIENCY IN TOMATO LEAF.

FIG. 66

FIG. 66. MAGNESIUM DEFICIENCY IN TOMATO LEAF.

doors where there is a draught. Beginning towards the base of the plant, the margins of the leaflets turn upwards and roll in towards the midrib, exposing the under side of the foliage to the observer's view. Varieties differ somewhat in the degree to which they are affected. The leaflets may either remain cupped or rolling may progress until their margins meet or even overlap, when they then present a funnel-shaped appearance, and at the same time feel tough and leathery. The basal leaves only may be affected or three-fourths of the foliage rolled. Such rolling neither appears to interfere noticeably with the growth of the plant nor with its fruiting capacity, Fig. 60, Plate XXX.

The above symptoms on tomatoes are very similar to those of potato plants diseased with the virus disease leaf roll, but the common rolling of tomato leaves is not caused by virus infection and it appears to be a low temperature effect.

INTUMESCENCES AND OEDEMA OR DROPSY

This rough warty condition of the leaves or stems seldom develops on out-door plants, but it may be quite common on those grown under glass. The malady is chiefly due to physiological reactions of the plant produced by a combination of environmental factors, for instance a warm moist soil combined with a saturated atmosphere, or anything which stops or retards transpiration. Excess of water in the plant is the predisposing cause in the development of the trouble. Under excessive absorption by the roots and reduced transpiration an abnormal turgidity is produced in the epidermis, spongy parenchyma of the leaf or cortical tissues of the stem. Groups of cells are thereby stimulated to grow and divide, forming little pustules of thin-walled cells almost devoid of chlorophyll. Owing to internal pressure the outermost of these extruded cells often collapse and give a brownish appearance to the pimples. Such proliferations generally show first on the under sides of the foliage but they may be present on both surfaces and also develop on other organs. When the excrescences are small they are usually called

Intumescences, but when they become well developed, forming white or brownish furry blisters, or ridges, the condition is then referred to as Oedema or Dropsy, Figs. 61 and 62, Plate XXXI.

The production of Oedema can also be favoured by applications of oil emulsions which are used for the control of red spider. Sprays of this type reduce transpiration and their use is occasionally followed by the development of Dropsy. Where oil emulsion sprays are being used the soil should be kept on the dry side and thorough ventilation and good lighting of the house are recommended after spraying.

NITROGEN DEFICIENCY

A DEFICIENCY of nitrogen may show up in tomato plants at any period of growth. Except in soils very deficient, there is usually enough nitrogen to support growth in the seedling stage and symptoms only appear later. The supply may be adequate for the normal growth of the plant but becomes exhausted when the plant is carrying fruit, in which case symptoms may develop suddenly.

The need of nitrogen in tomato plants is recognized by a slowness of growth, accompanied by the production of spindly shoots and a general change in colour of the foliage. On the top of the plant the leaves are thin, small, and take on a lighter shade of green than normal. The remainder of the foliage changes to pale green ; yellow blotches develop between the veins, and in severe cases the entire leaf blade becomes yellowish. There is more discoloration of the foliage on the lower part of the plant than on the top, and the plants present a general unthrifty appearance. The veins on the under sides of the leaves turn reddish-purple, and a similar colour appears in the stems which become hard and woody. Flower buds turn yellow and drop. Fruit on nitrogen starved plants is pale green while immature but it becomes highly coloured when ripe.

Nitrogen deficiency can be remedied by applications of a quick acting nitrogenous fertilizer to the soil The substances

generally employed for this purpose are sulphate of ammonia and dried blood. They may be used independently or together. Dried blood also contains potassium and phosphatic compounds. Its use is preferred by many growers, and when used alone the rate of application is 2½ to 5 cwt. per acre, further dressings being given at intervals of ten to fourteen days as required.

PHOSPHOROUS DEFICIENCY

A DEFICIENCY of this element has already been mentioned under the heading "Blue or Purple Discoloration of Seedlings and Young Plants," page 66, where it is stated that phosphorous may be rendered unavailable during the process of sterilizing soil for seed-boxes. The symptoms of its deficiency in older plants are very similar to those indicating lack of nitrogen, these are stems fibrous, short and thin, leaves small and veins purple. Inadequate supplies of phosphorous are usually made known by the bluish-green colour of the foliage and the tendency for the younger leaf blades to become purple underneath. The fruit is slow to set and of poor quality.

Purple tinting and bronzing of the older foliage also results from a want of phosphorous, but too much reliance should not be placed on this discoloration as a diagnostic character, as older foliage becomes discoloured from a variety of causes and it is common on tomatoes under glass.

Phosphorous deficiency is corrected by dressings of super-phosphate to the soil. This artificial manure is fairly rapid in action.

POTASH DEFICIENCY

POTASH deficiency results in a change in colour of the foliage followed by the occurrence of spots and death of the tissues. In soils very deficient of this element the symptoms first appear on the basal leaves and the plants remain stunted. Where

supplies of potassium have been adequate for the early stages of the plant's growth but are getting depleted, the symptoms appear towards the middle of the plant and then progress upwards, and they may develop rather suddenly after a period of rapid growth. Very often in glasshouses a lack of potash becomes evident towards the end of the growing season, the tops of the plants being affected worst.

The margins of the older leaves turn ashen grey-green at first, with a yellowish-green at the junction of the normal tissue. The tips of these leaves soon become brown, and yellowish spots form between the veins. In the younger foliage the margins become yellowish, dry out, die and curl up, and scorch is severe, Fig. 63, Plate XXXII. In all cases the damage begins at the margins and advances towards the midrib. Fruit ripens unevenly. Not infrequently the curled dead margins of the scorched leaves become covered with *Botrytis cinerea*.

Sulphate of potash is the best source of potassium for tomatoes as it is quick acting. Plentiful supplies of phosphorous and potassium make plants resistant to cold and fungus infection, and also tend to counteract the effects of too much nitrogen.

IRON DEFICIENCY

Where any scarcity of iron occurs in the soil or where the supply is rendered so insoluble that tomato plants have difficulty in absorbing enough for their requirements, symptoms of the deficiency appear in the top leaves. A very uniform pattern is presented in this case, as the mesh work of small veins besides all the larger ones remain green, this colour practically disappearing from the interveinal tissue, which becomes more or less transparent, Fig. 65, Plate XXXIII. Even in the case of well grown plants their tops may show this appearance near the end of the growing season. Other secondary effects of lack of iron are somewhat spindly tops and the fruit in the immature state whitish-green in colour. Where iron deficiency becomes severe through continual cultivation of tomatoes on certain soils,

FIG. 67. CREOSOTE DAMAGE ON YOUNG TOMATO PLANT.

PLATE
XXXV

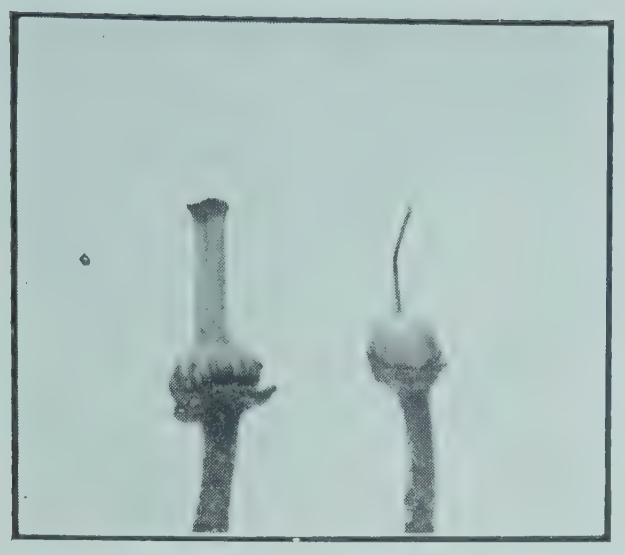

FIG. 68

FIG. 69

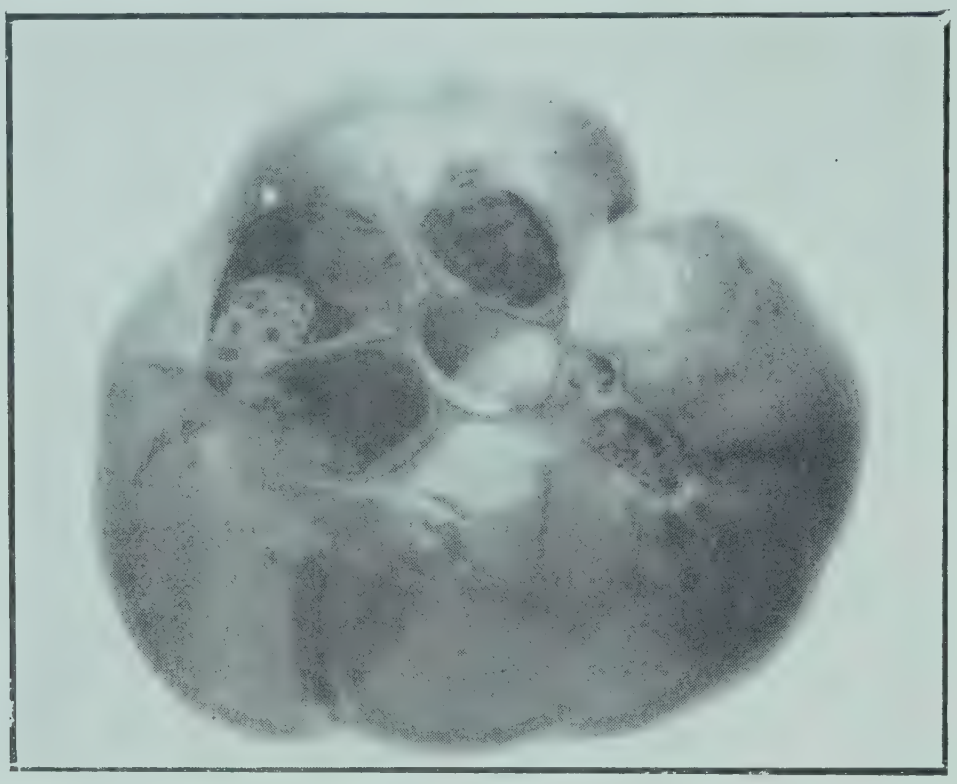

FIG. 70

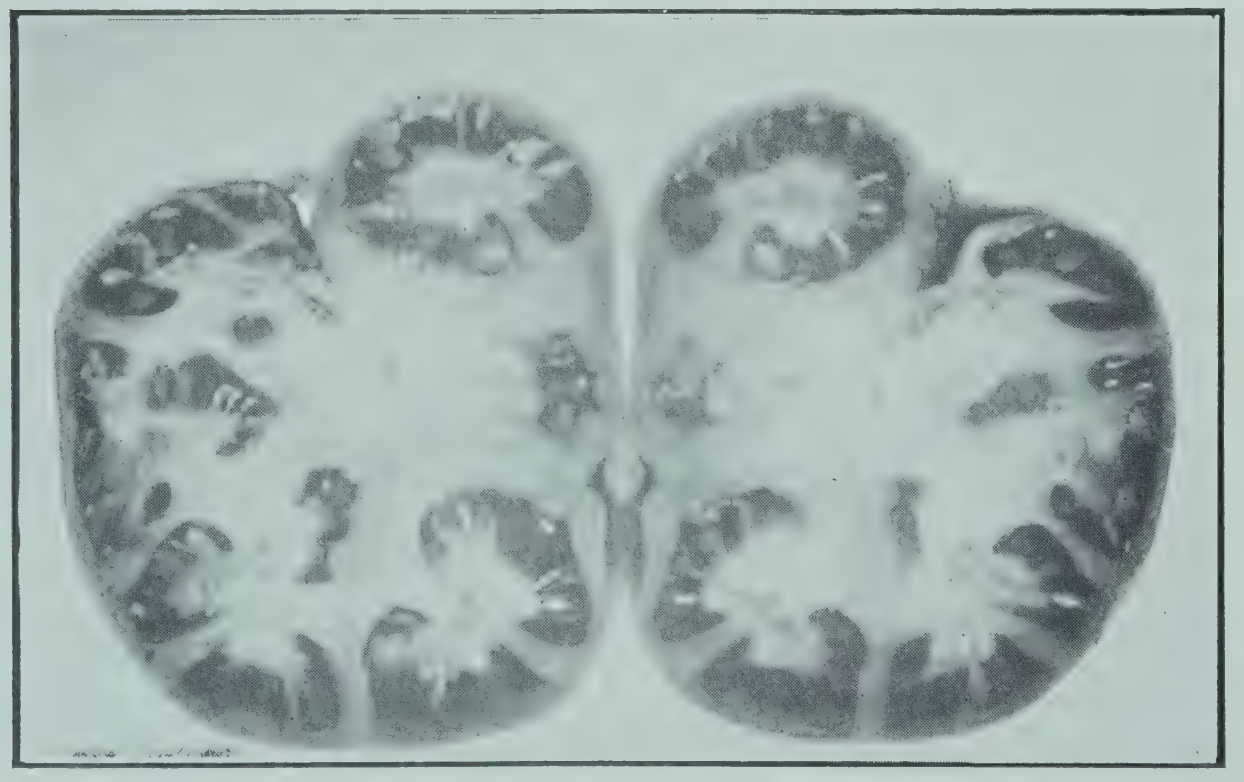

FIG. 71

FIG. 68. LEFT, ABNORMAL COMPOUND STYLE OF TOMATO FLOWER: RIGHT, NORMAL STYLE OF TOMATO FLOWER. FIG. 69. DOUBLING OF FLORAL PARTS OF TOMATO PLANT: NUMEROUS PETALS HAVE BEEN REMOVED. FIG. 70. COMPOUND TOMATO FRUIT DUE TO COALESCING OF SEVERAL STYLES AND OVARIES. FIG. 71. COMPOUND FRUIT CUT OPEN.

a chronic condition is set up in the plants so that they remain stunted and fail to fruit.

Plants showing affected foliage on their tops near the end of the growing season may be sprayed with a 0.1 per cent. solution of sulphate of iron (Ferrous sulphate). The solution is best applied in dull showery weather to the affected foliage only, and as the iron is soon immobilized in the leaves, several applications may be necessary at intervals. After spraying, usually some recovery to the normal green colour occurs in about a week's time.

Where a chronic condition exists a different procedure is necessary and the following treatment is that recommended by Pizer and Downes. A mulch of well moistened peat one and a half inches in depth is applied to the plants, and this is watered with a solution of sulphate of iron at a strength of one ounce iron sulphate dissolved in one gallon of water, this quantity being applied to each square yard. In this case, care should be taken to prevent the solution coming into contact with the leaves, because if it does severe scorching occurs.

REFERENCE :

PIZER, N. H. and DOWNES, W. F.—Iron Deficiency in Glasshouse Tomatoes. *Journal of the Ministry of Agriculture, London*, Vol. LII, pp. 120-122, 1945.

MAGNESIUM DEFICIENCY

THE lower leaves of the plant show symptoms of a deficiency of magnesium first. In the early stages a diffuse yellow blotch without any very clear line of demarcation appears on the central portion of the leaf-blade adjacent to the midrib. As time passes the yellow colour becomes more intense, the chlorophyll disappearing from the small meshwork of veins, but the midrib and larger side veins retain their green colour, the remainder of the lamina being bright yellow, Fig. 66, Plate XXXIII. The chlorosis is worst on the middle and base

of the plant, but it progresses rapidly towards the upper foliage as the season advances. In bad cases it causes death and defoliation of the older leaves.

This discoloration, due to a lack of magnesium, is common in glasshouses where tomatoes have been grown in the same soil for several years under heavy applications of potash. Magnesium may be present in the soil in quantity but it is apparently rendered unavailable to the plant through continuous heavy dressings of potash. Steam sterilization of such soils often corrects this unavailability to some extent. In other cases, Jones, Nicholas and Wallace (1), good results have been obtained by the addition of four to eight cwt. of magnesium sulphate per acre to the basic fertilizer dressing, withholding at the same time, dressings of potash. This would seem the logical method of control, but Walsh and Clarke (2) point out that heavy dressings of magnesium sulphate to the soil are undesirable. They recommend growing tomatoes in such soils without further application of potash, and this eventually leads to a proper balance between potassium and magnesium in the soil.

REFERENCES :

1. Jones, J. O., Nicholas, D. J. D., and Wallace, T.—Experiments on the Control of Magnesium Deficiency in Greenhouse Tomatoes. *Annual Report of the Agricultural and Horticultural Research Station, Long Ashton, Bristol*, 1943, pp. 48-53.
2. Walsh, T. and Clarke, E. J.—A Chlorosis of Tomatoes in Relation to Potassium and Magnesium Nutrition. *Journal, Royal Horticultural Society*, Vol. lxx, pp. 202-207, 1945.

CHEMICAL INJURY

Tomato foliage is very sensitive to certain gases and chemicals. It has been shown by Doubt (1) that the tomato is one of those plants admirably adapted for use as a test plant for the presence of illuminating gas in a greenhouse, as the response is definite, striking, and not easily mistaken. Tomato plants have also been tried for detection of fire-damp in coal mines, reacting to

traces of it much more quickly than canaries, which were generally used for this purpose.

Mention has already been made on page 15 of injury liable to be caused by chemical residues present in drip water, as the result of burning sulphur in glasshouses containing zinc. Another type of damage is produced by Creosote, whether it is used on woodwork or painted on hot-water pipes. In the latter case, even though the substance is applied in September or October severe effects follow the turning on of the heat in spring. The young plants become distorted and leaflets may be entirely suppressed or the laminae reduced, Fig. 67, Plate XXXIV.

Ortho-dichlorbenzene. Where this substance was used as a soil sterilizing agent severe abnormalities of the foliage occurred, Western and Stewart (2). These authors report that the malformation did not begin to appear until about seven weeks after planting, the fifth, sixth and upper leaves being distorted. The laminae were reduced and often consisted only of a thin band of assimilating tissue along the veins. The plants were stunted at first but afterwards grew away ; sometimes the fruit was distorted and the yield was reduced. The ill effects of such a soil chemical can persist for more than one year.

REFERENCES :

1. Doubt, Sarah L.—The Response of Plants to Illuminating Gas. *Botanical Gazette*, Vol. lxiii, pp. 209-224, 1917.

2. Western, J. H. and Stewart, R.—The Effect of a Chemical Soil Sterilizing Agent on the Subsequent Development of Tomato Plants. *Annals of Applied Biology*, Vol. xxx, pp. 370-372, 1943.

V. Miscellaneous Troubles

THE three items included under this heading could perhaps be classified under the term Undesirable Genetical Factors, as they all appear to be inherited characters. The smooth, symetrical fruit which we know to-day is a considerable improvement on the rough variable types in cultivation over a century ago, and the modern tomato is the result of much hybridization and selection. It is not surprising, therefore, that abnormal plants frequently occur. In some cases the abnormality may show up at an early stage in the seed-boxes, but in other instances the plant may be producing flowers before anything curious is noticed. Inherited characters are of course not infectious.

CATFACED FRUITS

THIS is the name given by American tomato growers to abnormal compound fruits as illustrated in Fig. 70, Plate XXXV. In some quarters it is believed that prolonged periods of very cool weather cause serious disturbances in growth during flowering and the result is this type of fruit, but there is no convincing evidence of this being the true explanation. Certain varieties are liable to this malformation, and such compound fruits appear to be due to inherited factors or to heterozygous plants. Doubling of various parts of tomato flowers is not uncommon in the progeny of plants wherever cross-pollination has occurred. Where multiplication of the floral organs occur, an increase in number of the female parts of the flower is most likely to take place, Figs. 68 and 69, Plate XXXV. This multiplication and subsequent adhesion of the pistils results in the production of abnormal fruit. On plants producing distorted blooms very often the set of fruit is poor, as many flowers are sterile owing to the lack of pollen, the anthers being replaced by sepals or petals. When plants have a tendency to double their floral organs all the flowers are usually abnormal, but

FIG. 72. LEFT, ROGUE PLANT OR CHRISTMAS TREE. RIGHT, NORMAL TOMATO PLANT.

FIG. 73. TOMATO LEAF SHOWING THE CONDITION KNOWN AS FERN LEAF.

individual flowers differ greatly in the degree to which the various parts are affected. It will generally be found that where plants produce abnormal flowers and fruit a considerable number will show the phenomenon in a particular batch of plants.

Varieties prone to this habit should not be grown, and if any plants are noticed in the house they should be rogued out early, and especially so if it is desired to save seed from plants in the same house.

ROGUES OR CHRISTMAS TREES

Tomato flowers are usually self-fertile and many modern varieties breed remarkably true, but in almost any group of tomato seedlings departure from type may occur, resulting in considerable variation and abnormalities. The most frequent and objectionable of these consist of plants known in this country as " Rogues " or " Xmas Trees," but also referred to by growers as " Fir Trees," " Fern Leaf " and " Nettle Head." These rogue plants are easily discernible to the practised eye, even in the seed-boxes. The main characteristics of such undesirable plants are first, the short internodes of the stem, and secondly, the premature growth of the axillary buds ; these two factors resulting in a dwarf bushy habit, Fig. 72, Plate XXXVI. Another more variable feature is the fern-leaved appearance of the foliage due to reduction of the laminae of the leaflets, Fig. 73, Plate XXXVII and Fig. 75, Plate XXXVIII. This fern-leaved appearance is not to be mistaken for virus infection, as it is not infectious and cannot be transmitted by grafting. Intermediate types between true rogues and normal plants also occur and these may escape detection until after planting out. The lower truss of these intermediates is nearly always malformed or withers before flowers develop.

Where growers save their own seed, it is always wise to reject any plant which appears at all doubtful in character of foliage or fruit.

LEAF SPOTTING IN THE PROGENY OF VETOMOLD

One way of combating disease in plants is to breed varieties resistant or immune to particular maladies. Very often, however, resistance to disease is bound up with undesirable characters, thus making the plant breeder's work extremely difficult. The variety of tomato Vetomold is an example of this sort. Vetomold was raised in Canada, and although not completely immune to all strains of *Cladosporium fulvum* it is strongly resistant or immune to most of the prevalent strains of Tomato Leaf Mould. Following the introduction of Vetomold into Great Britain in 1939-'40, and its subsequent distribution in these islands, growers were disappointed in its yield and quality of its fruit. Attempts were then made to get Vetomold's resistance to Tomato Leaf Mould into good quality heavy cropping varieties. Numerous crosses with the best commercial kinds were made and the progeny widely distributed in Ireland, only to find fresh trouble. This was a severe spotting of the foliage which appeared in the second generation wherever the progeny of Vetomold crosses was grown, and numerous complaints were forthcoming from growers.

This spotting varies from slight to severe, and is accompanied by a reduction in yield which is correlated to the time of its appearance and its intensity. Although some spotting may occur on the lower leaves at an early stage of the plant's growth, it often becomes intense when the plants are about three to four feet high, developing worst on the foliage about one-third of the way down from the top of the plant. The earliest symptoms are the appearance of faint yellowish-green spots on the leaflets. At first the spots are rather indefinite in outline on the upper surface. Soon they become bronze in colour, enlarge, varying in size from one to five mm. in diameter, and the outline becomes rather definite being somewhat angular. The bronzing is followed by the development of a more or less yellow area around the spot, which soon becomes necrotic. The spotting now becomes much more obvious and particularly so on the under surface of the foliage, Fig. 74, Plate XXXVIII. Some leaflets

only of a leaf may be affected and the spots may be few or many. Where they are numerous, the intervening spaces turn yellow, dry up and the spots coalesce. In severe cases complete destruction of affected foliage occurs, the leaflets drying up and withering from their tip or margin, Fig. 76, Plate XXXIX, and many of the upper trusses fail to set. The absence of any markings on the petioles, stems and fruit serve to distinguish this trouble from streak diseases.

Attempts made at Glasnevin failed completely to demonstrate any pathogenic organism or virus present in affected plants. Furthermore, during the years in which this spotting has been under observation it has never spread to the ordinary commercial varieties alongside affected plants. Clarke and Sherrard (1) were the first to draw attention to this undesirable trait in the progeny of Vetomold. Their evidence suggests that the trouble is genetical in nature, the leaf spot behaving as a recessive character which is bound up with resistance to *Cladosporium fulvum*.

This necrotic leaf spotting was intensively investigated by Langford (2) in Canada, and its genetical relationship with resistance to Tomato Leaf Mould fully established. For a discussion on this phenomenon and its importance in breeding tomatoes, the reader is referred to Langford's paper, (ibid.).

REFERENCES :

1. Clarke, E. J. and Sherrard, G. O.—A Leaf-Spot on Tomatoes and its Relationship to the variety Vetomold. *Gardener's Chronicle*, No. 3034, P. 71, 1945.

2. Langford, A. N.—Autogenous Necrosis in Tomatoes Immune from *Cladosporium fulvum* Cooke. *Canadian Journal of Research*, Section C, Vol. xxvi, pp. 35-64, 1948.

VI. Damage Due to Animals

INSECT pests of the tomato are not included in this publication, but two types of damage caused by small animals (WOODLICE and SYMPHYLIDS) are described. In both these cases the pest is seldom seen committing its depredations, and the resulting damage is often mistaken by the grower for fungus attack. Injured plants of both types have been received time and again at the Department of Plant Pathology, but in only one instance has the responsible pest been forwarded along with the plant. The damage caused in each case is very characteristic, and once diagnosed it cannot easily be mistaken for anything else. Where injured plants of either type are found, a careful search of the soil in their neighbourhood will reveal the causal pest.

DAMAGE CAUSED BY WOODLICE

Armadillidium vulgare LATR.

THESE animals do not require any description as they are only too familiar to everyone who has worked in a garden. The common Woodlouse is known as *Armadillidium vulgare* Latr., but there are several species which are a nuisance in glasshouses. Although their usual food is decaying organic matter, Woodlice also attack many kinds of plants. As they are nocturnal feeders they are seldom seen committing the actual damage and the injury they do is often attributed to slugs.

SYMPTOMS OF ATTACK. Tomato plants may be attacked either in the seed-boxes or after they have been planted out in their permanent quarters. The cortex of the stem at ground level is gnawed and destroyed, the damage varying from a slight fraying of the stem-surface to complete destruction of the cortex, resulting in a girdling of the base of the stem, Fig. 77, Plate XL. There is no blackening or other discoloration of the adjacent uninjured cortex, and the stem often swells immediately above the girdled portion and tends to throw out

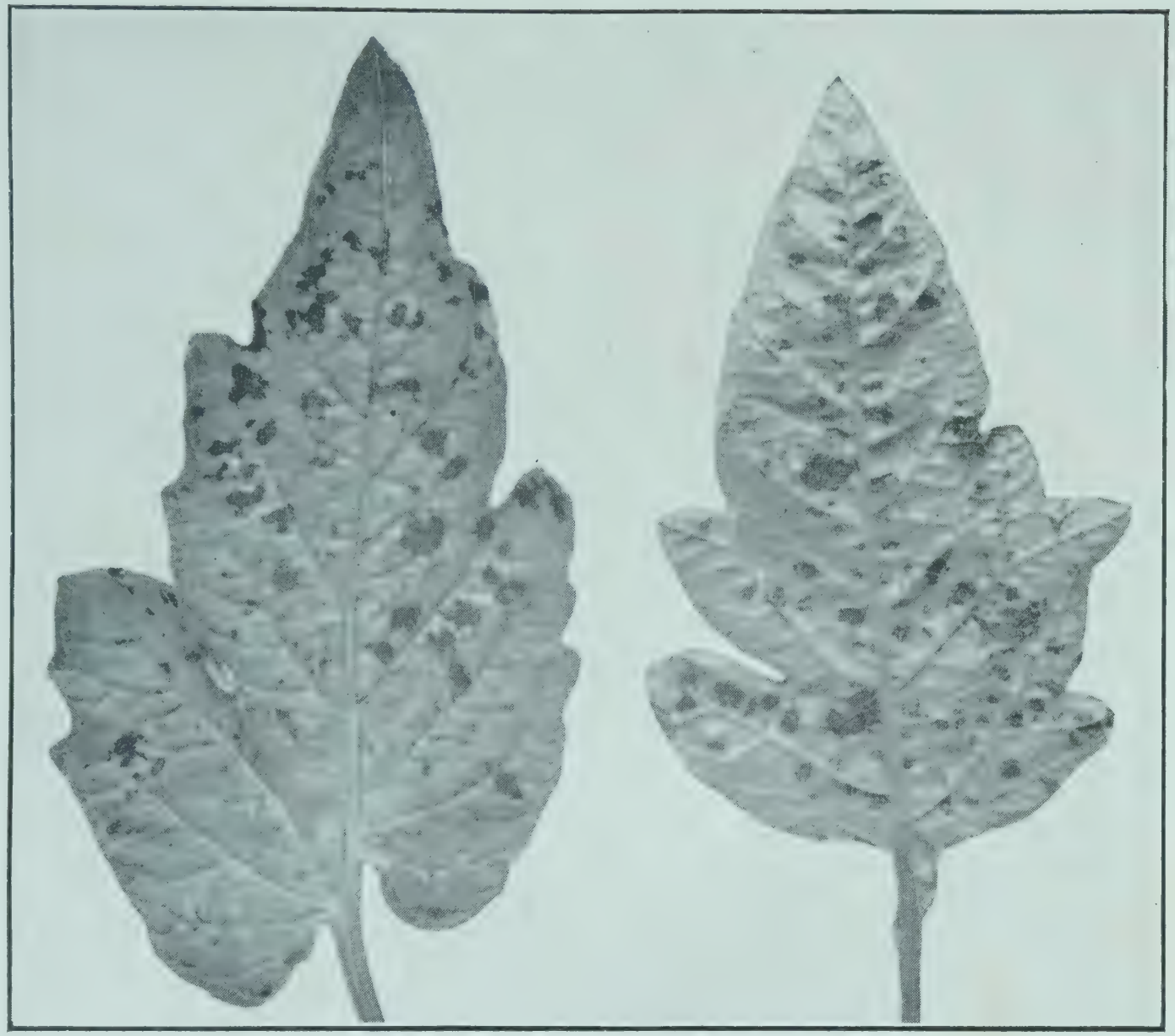

FIG. 74

FIG. 75

FIG. 74. UPPER AND LOWER SURFACES RESPECTIVELY OF TOMATO LEAFLETS SHOWING NECROSIS DUE TO VETOMOLD SPOTTING.
FIG. 75. ANOTHER TYPE OF FERN LEAF IN TOMATO FOLIAGE.

FIG. 76. TOMATO LEAF SHOWING SEVERE SHRIVELLING AND DYING OF LEAFLETS DUE TO VETOMOLD SPOTTING.

roots. Where plants are being attacked in this manner, an examination of the soil at their base will reveal the animals sheltering just beneath the surface. Severe attacks of Woodlice have followed planting out tomatoes in a house where chrysanthemums in pots had stood all winter, while other parts of the same house which had been cropped with winter lettuce and then planted with tomatoes were free from this pest.

CONTROL. Plants which have been injured, or even completely girdled by Woodlice, will of course survive if the stems are well mulched up above the damaged areas. The accumulation of rubbish of any kind, rotten wood, old boxes or pots, should be avoided in glasshouses. Where Woodlice are not too numerous they may be trapped by means of cut slices of carrots, beet or mangolds. If such traps are smeared with Arsenate of Lead or Paris green most of the animals will be poisoned ; alternatively the traps should be examined daily and the Woodlice collected and destroyed. Where infestation is severe poison bait may be used. This may consist either of ½ lb. of Paris green thoroughly mixed with 14 lb. of bran and distributed at the rate of ½ oz. per square yard, or 1 lb. Paris green mixed with 50 lb. dried blood and scattered at the rate of 1 oz. per square yard.

Woodlice which are sheltering in crevices around walls, supports and similar places can be destroyed by drenching these situations with boiling water, or with an emulsion made up of 1 gallon cresylic acid, 1 lb. naphthalene, 8 lb. soft soap and 98 gallons of water.

SYMPHYLID INJURY

Scutigerella immaculata NEWPORT

SYMPHYLIDS are delicate, slender whitish creatures measuring about one quarter of an inch in length, possessing twelve pairs of legs when mature, a pair of tail feelers and a distinct head which is furnished with long slender antennae. In the immature

state the antennae and tail feelers are short, and the animals start life with six pairs of legs. With each moult the length of the feelers and the number of legs increase until maturity is reached. Symphylids generally frequent the upper foot of soil but when conditions there become unfavourable they bury themselves deeper and may penetrate the subsoil. They are rather difficult to find in the soil as they are very active and quickly disappear when disturbed.

The common Symphylid, *Scutigerella immaculata* Newport, is a normal soil inhabitant, which tends to become numerous in garden soils where there is plenty of organic matter. It has become a serious pest in many nurseries and commercial glasshouses, attacking the underground parts of various plants. Wherever it becomes established in glasshouses it is very destructive to tomatoes.

SYMPTOMS OF ATTACK. The attack often begins shortly after the plants are set out in their final position and the crop soon appears patchy. Affected plants occur in irregular groups or areas, as the Symphylids are inclined to congregate together, especially near walls, pillars and hot-water pipes. In the infested areas the plants make practically no growth, remaining more or less at a standstill. The stems become purplish, the upper foliage assumes a dark green colour and the lower leaves turn yellow, and wilting occurs during the daytime. Where infestation is heavy the plants die. When affected plants are dug up the most striking symptom is the appearance of the root system. This seems as if it had been trimmed with a pair of scissors, Fig. 78, Plate XL, and it also presents a slightly galled appearance. Close examination shows that there is an entire absence of new roots, for they have been devoured as fast as they appeared. Owing to this repeated destruction of new roots the ends of existing roots are somewhat swollen as the result of callus formation. In addition, many of the older roots will be found to be damaged, corky calluses developing over the injured tissue.

CONTROL. Measures for control should be taken during the dormant season. Steam sterilization of the soil has been

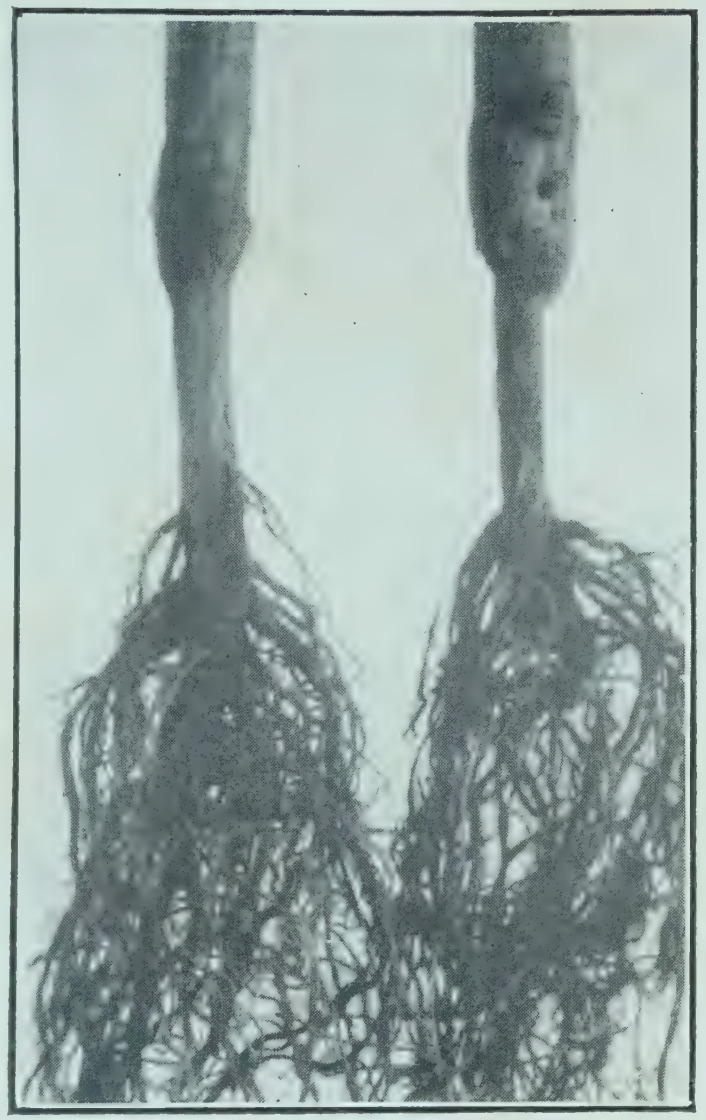

FIG. 77

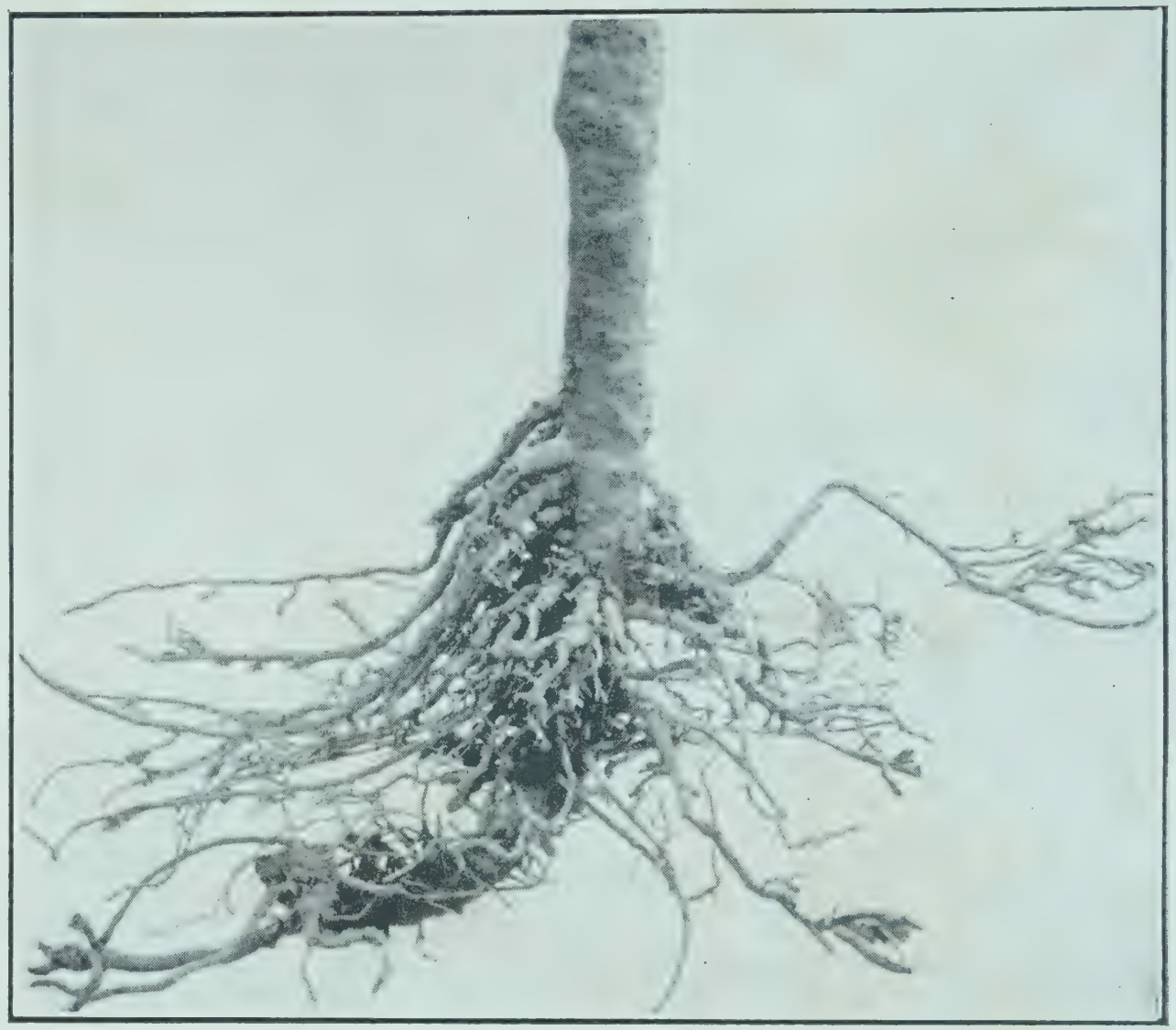

FIG. 78

FIG. 77. TOMATO STEMS GIRDLED BY WOODLICE, *Armadillidium vulgare*.

FIG. 78. ROOT SYSTEM OF TOMATO PLANT SHOWING INJURY CAUSED BY SYMPHYLIDS, *Scutigerella immaculata*.

PLATE
XLI

FIG. 79

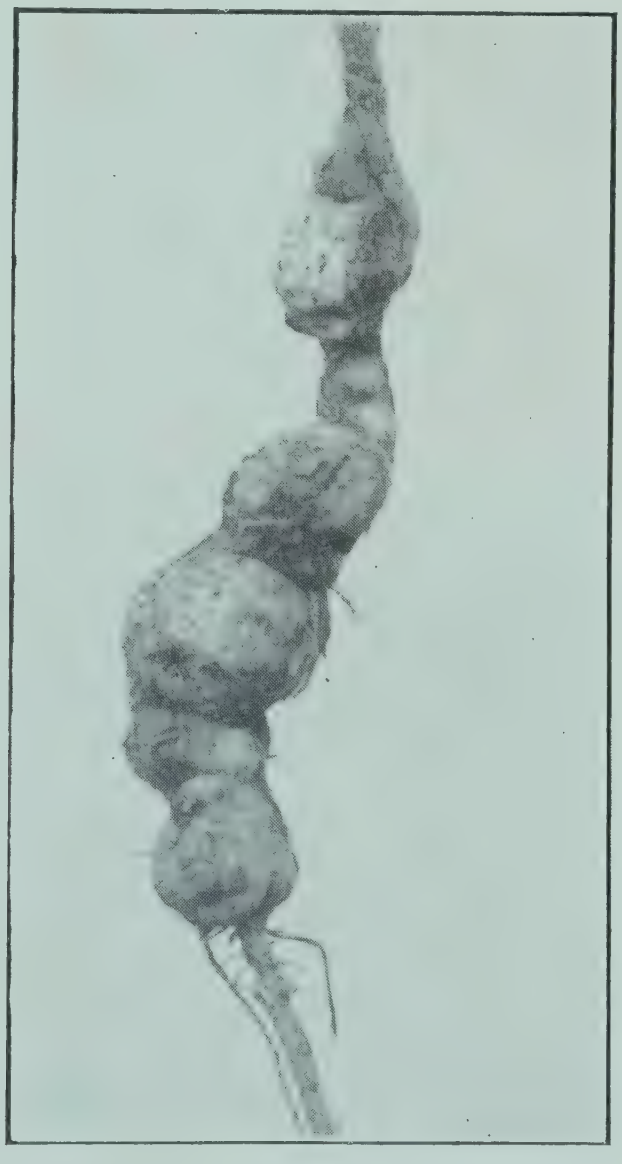

FIG. 80

FIG. 79. ROOT SYSTEM OF TOMATO PLANT INFESTED WITH THE ROOT KNOT EELWORM, *Heterodera marioni*.

FIG. 80. GALLS ON ROOT OF TOMATO PLANT DUE TO THE ROOT KNOT EELWORM: NATURAL SIZE. NOTE, ABSENCE OF FINE ROOTS FROM GALLS.

found to be the most effective way of dealing with Symphylids. Before such treatment is carried out the Symphylids should be induced to come to the surface layers of the soil. This is achieved by raising the soil temperature and sowing a crop of cress or rape. After the young plants appear a sufficient interval should be allowed for the Symphylids to assemble near the surface, and the soil should then be thoroughly sterilized to a depth of eighteen inches. The number of Symphylids present may also be reduced by applications of cresylic acid. This should be of 97–99 per cent purity and diluted to the strength of one gallon in thirty-nine gallons of water. This amount being sufficient to treat ten square yards of soil. The dilute solution is watered over the surface of the soil, thoroughly saturating the top couple of inches. The soil is then dug to a depth of one foot, the saturated layer being skimmed off and placed in the bottom of the spit as digging proceeds.

Where the presence of this pest is not suspected until after the house has been planted, its attacks may be minimised by chemical treatment. Paradichlorbenzene scattered close to the plants when the soil is moist and applied at the rate of 1 oz. per yard of plant row is quite effective. Mercuric chloride may also be used, using a dilute solution of 1 oz. mercuric chloride in 10 gallons of water. Attacked plants may be heavily watered with this solution without risk of damage.

VII. Eelworms

NEMATODES or EELWORMS are very small unsegmented worms usually classed amongst the round-worms. Some of them are free-living forms commonly found in decaying organic matter, but others are destructive parasites causing great loss to cultivated crops. Many of those forms parasitic on plants are too small to be visible without the aid of a lens or microscope, yet some are just big enough to be seen by the unaided eye

Eelworms found attacking tomato plants may be divided into two main groups :

(1) That in which both sexes retain their eel-like shape throughout their existence.

(2) A group in which the shape of the female changes completely after fertilization, that is, from being eel-like the female becomes a spherical or pear-shaped body known as a CYST.

It is the latter group especially which is of chief interest to tomato growers, as it includes two species which are malignant parasites, namely, *Heterodera marioni* and *Heterodera rostochiensis*. These two species resemble each other in the morphological change of the females after fertilization into cysts, and both are soil inhabitants. In spite of these similarities, the reaction of the plant's roots is entirely different to the attack of each species, and the underground diseased symptoms are totally unlike in character.

When eelworms become established in glasshouses, very often great difficulty is experienced in eradicating them. Therefore, all possible precautions should be taken to prevent the introduction of these pests.

THE ROOT KNOT EELWORM

Heterodera marioni (CORNU.) GOODEY

THE Root Knot Eelworm is known to occur on over five hundred species of wild or cultivated plants, producing characteristic swellings or galls on the roots of many of its hosts. The ravages caused by this nematode are worst in tropical or semi-tropical regions, where the parasite may pass through ten or twelve

generations in a year. In the cool temperate climate of Great Britain and Ireland this eelworm is only of frequent occurrence on light sandy soils in glasshouses, where the relatively high soil temperatures favour its development. Under these conditions cucumbers and tomatoes are the hosts generally parasitized by it, but other greenhouse crops, such as beans or lettuce, are not immune when planted in infested soil. Although this eelworm was known in England in 1855, it apparently was not recorded from Ireland until 1910, when Carpenter (1) reported it on tomato roots received from Belfast. Fortunately, the disease is still rather rare in this country.

SYMPTOMS ON TOMATO. As would be expected, the aerial signs of the disease vary with the degree of infestation on the underground parts, and with the time the attack reaches its maximum development. Where root infestation is severe early in the season young plants may be rapidly killed. Usually the plants develop three or four trusses of fruit before the roots are badly attacked. As this proceeds, the foliage turns a pale sickly green colour, and the leaves become necrotic at their margins ; the plants are stunted and wilt during warm weather ; and fruit may be either wanting, or if present it remains small and undeveloped. Many diseased plants die prematurely, but others less heavily infested may survive until near the end of the season.

Very characteristic symptoms appear on the roots, Figs. 79 and 80, Plate XLI. A root may be attacked at intervals giving it a beaded appearance, or it may be swollen throughout its entire length. In severe cases the whole root system may be involved. The galls vary in size and shape, ranging from small pimples barely noticeable to irregular swellings two to three inches in diameter. Infested roots are practically devoid of fine feeding roots. When a gall is cut across dark specks in the cortex mark the location of the organism, and small glistening pearly bodies just visible to the naked eye are evident, these are female nematodes or cysts.

LIFE CYCLE. Primary infestation arises from eelworm larvae present in the soil. The larvae make their way to roots

of suitable hosts and gain entrance near to the growing points. Having taken up their position within the root tissues the larvae become stationary and feed on the tissues. The male and female larvae are similar in shape. Several stages of development are passed before maturity is reached, the males remaining eel-like but the females swell up and develop into cysts. Under favourable conditions the females may be producing eggs within thirty to forty days after primary infestation. When the weather is warm the eggs hatch within two to three days. Each female may produce from three hundred to eight hundred eggs. The latter are laid at the rate of ten to fifteen per day and deposited in a gelatinous mass which is attached to the cyst. Occasionally egg masses are extruded through the tissues to the outside of the root and the larvae are set free into the soil. When eggs hatch within the galled tissues, some of the larvae make their way out into the soil and set up new centres of infestation, others penetrate deeper into the root tissues and establish new colonies of the pest. In the final stages of the disease the galls contain numerous eelworms in all stages of development from eggs to cysts.

Immediately following attack a stimulation is set up in the host which induces giant cell formation around the head of the eelworm. The pest derives its nourishment from these enlarged cells. Other changes are also brought about by the parasite. The cortical tissue is stimulated to abnormal growth. The development of the root is interfered with, and its function interrupted through the disorganisation of the conducting vessels. The cutting off of food supplies to the top of the plant results in the aerial symptoms already described, the food being diverted to the swollen roots and leading to an accumulation of nutrients in the vicinity of the worms.

Heterodera marioni hibernates in the soil by means of eggs and larvae. Apparently larvae may survive for twelve months in the ground without food, but in the absence of host plants all are dead by the end of the second year. According to American investigators this nematode is sensitive to various environmental conditions, such as cold, heat, drought or water. The organism

dies out in soil which becomes dust dry or is subjected to prolonged flooding.

CONTROL. Every precaution should be taken to prevent the introduction of this pest. All plants known to be affected should be dug up and burnt, and in no case should they be thrown into the compost or manure heap. The two chief means of control are by rotation of crops and by soil sterilization. The latter is the only method available under glasshouse conditions.

(*i*) STEAM STERILIZATION. This is the effective way of controlling the Root Knot Eelworm. Other treatments which tend to reduce infestation may, however, be mentioned.

(*ii*) HOT WATER. Where the eelworm is only present on a limited scale boiling water may be applied at the rate of eight to ten gallons per cubic foot of soil.

(*iii*) FORMALDEHYDE. One gallon of forty per cent. formalin is added to forty-nine gallons of water, and applied to the soil at the rate of fifty gallons to every ten square yards. The soil is immediately dug over one spit deep, and covered for forty-eight hours with tarpaulins or sacks which have been steeped in the formaldehyde solution.

(*iv*) CARBON BISULPHIDE. This substance may be injected into the soil at the rate of sixty to one hundred grams per cubic yard, or it may be watered in as an emulsion. The latter can be made with equal parts of carbon bisulphide and sulphonated castor oil. It is used at a strength of one in sixty of water and the rate of application is three gallons per square yard.

(*v*) CALCIUM CYANIDE. This chemical may be used either in a dry state or in solution. For the former method ten pounds of calcium cyanide is applied to each fifty square yards of infested soil in the autumn. The solution is stated to give more satisfactory results. This is made by dissolving one pound of calcium cyanide in ten gallons of water and applying it at the rate of two gallons per square yard. The solution is best applied in the spring when the soil temperature has risen to about 48° F.

(*vi*) CRESYLIC ACID. One gallon of crude carbolic acid ninety-seven to ninety-nine per cent. purity is added to thirty-nine gallons of water. This dilute solution is applied at the rate of four to five gallons per square yard, and the soil is immediately dug over. A second dressing at the same strength should be given a week later.

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THE POTATO EELWORM

Heterodera rostochiensis WOLLENWEBER

UNLIKE the Root Knot Eelworm which lives on many plants indiscriminately, the Potato Eelworm confines its attacks to a restricted number of hosts. It was formerly believed that the Potato Eelworm was a strain of the Sugar Beet Eelworm (*Heterodera schachtii*), but it is now considered to be a distinct species and is therefore known as *Heterodera rostochiensis*, Goodey (1).

Although evidently present in a few localities for many years, this particular eelworm only came into prominence in Great Britain and Ireland during the early twenties of the present century, when it was found to be responsible for serious reduction of potato crops in certain areas. The pest is widespread in both islands. Districts worst infested are those where potatoes constitute the main crop and in consequence are grown on a very short rotation. This applies particularly to soils of a light sandy nature, which are just those most favoured by potato growers catering for early markets. Infestation is not, as a rule, severe on clay soils or under good farming practice in Ireland, but the Potato Eelworm has become established in many gardens and allotments, and it is undoubtedly on the increase.

Morgan (3) in 1925 showed that the Potato Eelworm was capable of attacking tomato plants, and according to Johnson and Thompson (2) it appears to have been observed occurring naturally on tomato roots in 1928. Serious attacks of the Potato Eelworm on tomatoes, resulting in complete failures, have been reported time and again during recent years, and the tomato plant appears to be as susceptible to infestation as is the potato.

SYMPTOMS. These on tomato plants resemble to a large extent those shown by infested potatoes. The affected plants occur in patches, which increase in size from year to year unless remedial measures are adopted. The plants are stunted and starved in appearance ; foliage a sickly yellowish-green, flagging, and shows every sign of defective root action. Diseased plants seldom exceed four feet in height, flowers remain closed or drop prematurely, and attempts are made to develop new roots from the base of the stems. When such plants are dug up the roots will be found to be more or less decayed, the cortex being brown and easily peeled off. The real diagnostic feature of this disease is the presence of whitish, yellowish or brown cysts (according to their age) protruding through the root tissues, Fig. 82, Plate XLIII. These cysts are loosely attached and in the case of the tomato they fall off readily.

When seedlings are raised in infested soil they are dwarfed and possess a very poor root system. Plants of this type if planted out into clean ground throw out fresh roots and will grow away, but it must be remembered that they infest the new ground. Alternatively, when healthy seedlings are transplanted into heavily infested soil they make practically no growth, Fig. 81, Plate XLII, and the general appearance of these plants is as if they were being plasmolysed by an overdose of artificial manures or by some toxic substance in the soil. The plants remain at a standstill, the lower leaves become brown, the discoloration appearing first at the margins of the leaflets and spreading in towards the midrib. Eventually, the bottom foliage loses its chlorophyll, dries up and drops off.

LIFE CYCLE. Larvae, which hatch from eggs contained in cysts in the soil, enter the young roots and feed mainly in

the cortical tissues. When sexually mature the larvae burst out through the root tissues, the males which are cylindrical and eel-like escaping into the soil. During the development of the female within the root, the body enlarges laterally without any corresponding increase in length, and as growth continues the rear part of the body protrudes through the root tissues, in which position it is found by the male and fertilization occurs. After fertilization egg production takes place with great rapidity, the females remaining attached to the root by their head portion, and they then appear as small white or yellowish bodies just visible to the naked eye. Growth of the protruding part is maintained, and ultimately the distended spherical body becomes completely filled with eggs, Fig. 83, Plate XLIII : the integument becomes a tough brown envelope, and finally the female dies and the resulting brown cyst drops off into the soil Cysts may contain anything from two hundred to four hundred eggs, and they can remain viable for at least nine years in the ground in the absence of host plants. Hence, soil once contaminated with this eelworm remains infested for a long time. During this period a few eggs may hatch each year, but hatching is greatly speeded up by the stimulating effect of root excretions of those plants on which the nematode lives. Consequently, when a susceptible crop such as the tomato is planted, numerous eggs hatch and the larvae burrow into the young roots.

Only one generation of *Heterodera rostochiensis* occurs in the year, and this eelworm lives and develops at a lower soil temperature than the Root Knot Eelworm, *Heterodera marioni*. There is no gall formation by the Potato Eelworm, but within the root the larvae set up serious disturbances, the xylem becoming displaced and distorted, the conduction of nutritive substance is interfered with, and the cortical tissues ruptured and damaged. The destruction of the root cortex is invariably hastened by the invasion of secondary organisms, which gain entrance through wounds made by the eelworm larvae.

Potato Eelworm may be introduced into glasshouses with infested soil or manure, or it may be brought in by means of potatoes used to trap wireworms, if such tubers have come from

FIG. 81. LEFT, TOMATO PLANT GROWING IN SOIL INFESTED WITH THE POTATO EELWORM, *Heterodera rostochiensis*. RIGHT, HEALTHY TOMATO PLANT, SAME AGE AS PLANT ON LEFT AND TRANSPLANTED AT SAME TIME INTO SOIL FREE FROM THE POTATO EELWORM

PLATE XLIII

FIG. 82

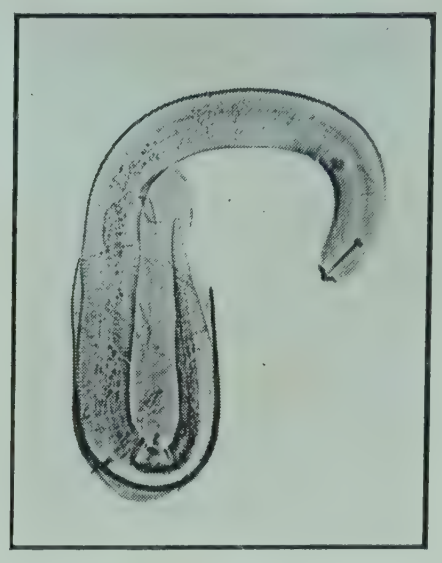

FIG. 85

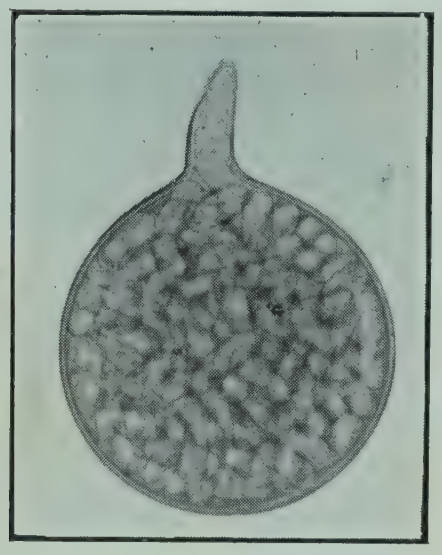

FIG. 83

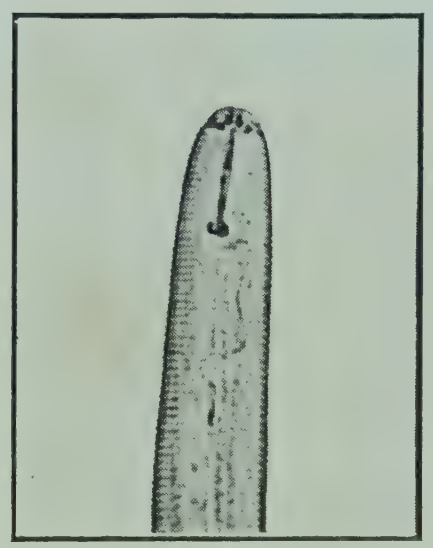

FIG. 86

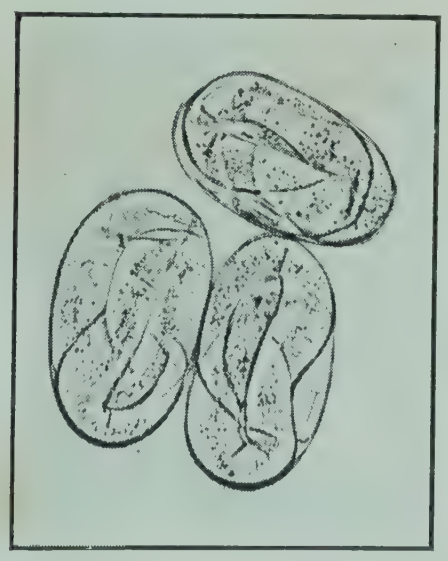

FIG. 84

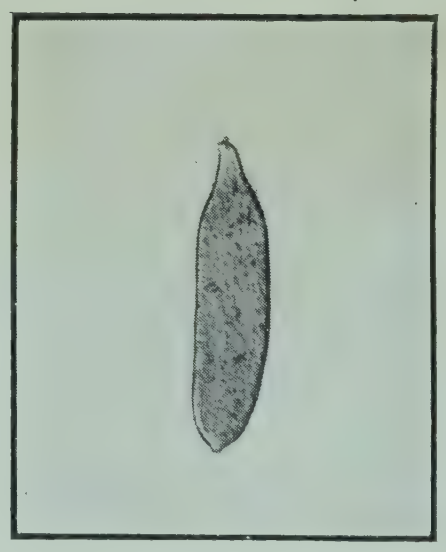

FIG. 87

FIG. 82. FEMALE CYSTS OF POTATO EELWORM, *Heterodera rostochiensis*, PROTRUDING FROM INFESTED ROOT.

FIG. 83. SINGLE EELWORM CYST CLEARED TO SHOW MASS OF EGGS. X 52.

FIG. 84. EELWORM EGGS REMOVED FROM CYST. X 200.

FIG. 85. YOUNG EELWORM EMERGING FROM EGG. X 200.

FIG. 86. HEAD OF YOUNG EELWORM. X 460.

FIG. 87. EARLY LARVAL STAGE OF FEMALE POTATO EELWORM. X 54.

infested soil. Owing to the increasing prevalence of this eelworm in gardens and allotments and in districts where potato sickness occurs, it is important that growers should take care that glass-houses are erected on clean soil, otherwise failures may be encountered from this pest in the first year's cropping. In this connexion it should be remembered, that in such areas, freedom from potato cropping for several years previously does not necessarily mean freedom from cysts in the soil.

CONTROL. The only satisfactory method of dealing with the Potato Eelworm under glass is by steam sterilization of the soil. Where this is properly carried out, all eggs and larvae in cysts are killed in the top eighteen inches of soil, and the succeeding crop is free from attack. Treatment with different chemicals, as in the case of the Root Knot Eelworm, gives some measure of control, but no chemical treatment is so effective as steam sterilization.

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1. GOODEY, T.—*Plant Parasitic Nematodes.* London, 1933.
2. JOHNSON, L. R. and THOMPSON, H. W.—Tomato Sickness in Yorkshire. *The Journal of the Ministry of Agriculture, London,* Vol. XLIII, pp. 48-54, 1936.
3. MORGAN, D. O.—Investigations on Eelworm in Potatoes in South Lincolnshire. *Journal of Helminthology,* Vol. III, pp. 185-192, 1925.

THE STEM AND BULB EELWORM

Anguillulina dipsaci KÜHN

THE chief difference between this species and the two nematodes previously described is the fact that in *Anguillulina dipsaci* the female does not form a cyst, both sexes retaining their eel-like shape throughout life. The Stem and Bulb Eelworm is common on many plants and often does great damage. Williams reports it attacking tomato plants and causing soft spongy growths or galls on the stems and leaves. Attacks of this kind have not yet

been recorded on tomatoes in Ireland, but as the species is prevalent a look out for its occurrence on this host should be kept.

REFERENCE :

WILLIAMS, P. H.—A New Eelworm Disease of the Tomato. *Gardener's Chronicle*, Vol. XCIX, No. 2577, p. 316, 1936.

VIII. General Observations

The maximum production of tomatoes under glass can only be attained by attention to details. One of the most important of these is to start with good sturdy plants in the house. Whenever it is at all possible growers should raise their own plants and avoid the danger of introducing disease into their houses. Complaints regarding failures after planting out are far more numerous with bought plants than where growers raise their own. Many amateurs and some commercial growers with limited facilities have to rely on bought plants, and good stocky plants can be purchased from men who pride themselves on their work. On the other hand, some nurserymen and gardeners (so-called) have found the raising of tomato plants a lucrative business, and their object is to sell the greatest number from the least possible space, heedless of how the plants turn out afterwards. Cases are not unknown to the writer where plants were bought with their roots already infected with *Colletotrichum atramentarium*, and in other instances with the foliage spotted by *Cladosporium fulvum*. Some of the former were actually purchased for planting in newly erected glasshouses. Too much care cannot be taken when buying plants. Around cities one often sees tomato plants exposed for sale in seed-boxes where they were sown. These have never been transplanted, are from eight to twelve inches high, lanky, and their roots poorly developed and matted together. Plants of this type are dear at any price. When such specimens are planted out it is not unusual to find about a third of them succumbing to various troubles inside the first month or six weeks.

Growers should not make the mistake of attempting to raise seedlings in sterilized soil taken from the tomato house. A natural assumption would be, that such a soil, presumably free from pathogenic organisms would be ideal for use in seed-boxes. Soil from a tomato house, whether sterilized or not, is totally unsuited for raising seedlings in on account of its concentrated

residues of mineral manures. These poison the roots and cause plasmolysis of the young plants.

Any transplanting naturally gives a check to the plant, and when setting out tomatoes in their permanent quarters the first aim should be to get the plants to resume growth as soon as possible. Bright sunlight and high temperatures which favour rapid transpiration make the plants prone to wilt ; cold, wet soils and too low temperatures delay their establishment. The longer this period is the more liable are the plants to invasion by parasitic fungi.

Strict cleanliness and hygiene about the tomato house cannot be too strongly emphasized, and all diseased plants or refuse of any kind should be burnt or buried. There is a great deal to be said for some of the methods of the older generation of gardeners. Tidiness with them was almost an obsession, and many of them believed in removing diseased or weakly plants rather than attempting to doctor poorly developed specimens. Both these points might be followed with advantage in many tomato houses to-day. In the early stages of growth particularly, growers would find it remunerative to remove all sickly or backward plants and replace them with good strong individuals rather than hope for the lagging plants to make good and bear a full crop.

Where insects attack tomatoes, prompt remedial measures are often effective and the attacked plants may recover fully. Similarly, in the case of non-parasitic diseases correction of the unfavourable factor usually leads to full recovery. Such is not the case, however, when tomatoes are invaded by fungi, bacteria, or viruses. It will, I think, be obvious to the reader, that once plants are invaded by these parasitic diseases recovery of the host can seldom be effected. The rule of the tomato grower therefore, should be prevention rather than cure. Prevention is really the fundamental basis for the control of parasitic diseases.

Mention has been made previously of plants which are kept at too low a temperature for satisfactory growth developing bluish or purple foliage. Quite a different appearance results from a sudden drop in temperature to freezing point on cold

nights, and in unheated glasshouses tomato plants not infrequently suffer from late spring frosts. All the plants throughout the house may be affected or only those nearest to the glass show damage. Usually the effects become noticeable within a few days after the frost has occurred. There may be more or less mottling of the foliage simulating Mosaic or the development of bright yellow areas on the tips and margins of the leaflets, the terminals being affected worst. With the advent of good growing conditions the plants soon develop young foliage which is normal, but the injured foliage persists, and the contrast between its discoloured appearance and the new growth is somewhat striking. In cases of more severe frost damage the yellowed areas die and dry up, and very often *Botrytis cinerea* establishes itself on the dead tissues.

Under climatic conditions in this country and especially in the more humid districts of the south and west, the control of Tomato Leaf Mould is a difficult problem. In attempts made to raise resistant or immune varieties some of the difficulties encountered have been referred to on page 84. Although the variety Vetomold is liable to infection with some strains of *Cladosporium fulvum*, it is very resistant or practically immune to those strains of the fungus commonly met with, and from a breeder's point of view it is undoubtedly the most promising sort yet introduced. As pointed out on page 84, when Vetomold has been crossed with some of the good commercial varieties certain undesirable traits appear in the second generation, but the first generation hybrids are free from these defects, resistant to Tomato Leaf Mould and crop reasonably well. It has been suggested, that pending the introduction of a really good variety resistant to Tomato Leaf Mould, hybrids might be raised each year between Vetomold and heavy cropping sorts in order to supply seed to those districts where the disease is a regular menace.* A certain amount of technical skill would be required for such work, but it is not beyond the capabilities of some

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* This suggestion was made to the writer by Professor G. O. Sherrard and Dr. E. J. Clarke, University College, Dublin, when discussing the control of this disease.

enterprising tomato grower, nurseryman or seedsman, and the matter is one well worthy of consideration.

Finally, when specimens are being sent anywhere for examination for disease, the entire plant should be forwarded, properly packed so that it will arrive at its destination reasonably fresh. Too often a single leaf or leaflet is placed in an envelope and sent through the post. When such a specimen is received, it appears as if a steam-roller had passed over it. It should be evident that it is only in a disease like Tomato Leaf Mould that anything can be made out from an examination of a single leaf. If the trouble is at the root of the plant, foliage is rarely of much use for diagnostic purposes, and in the case of virus diseases dried up or wilted leaves are useless.

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